# Sandia National Laboratories/New Mexico

# PROPOSAL FOR
# RISK-BASED NO FURTHER ACTION
# ENVIRONMENTAL RESTORATION SITE 44
# URANIUM CALIBRATION PITS AND
# DECONTAMINATION AREA
# OPERABLE UNIT 1303

September 1997

Environmental
Restoration
Project

United States Department of Energy
Albuquerque Operations Office

# PROPOSAL FOR RISK-BASED NO FURTHER ACTION ENVIRONMENTAL RESTORATION SITE 44 URANIUM CALIBRATION PITS AND DECONTAMINATION AREA OPERABLE UNIT 1303 September 1997

Prepared by
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Albuquerque, New Mexico

Prepared for
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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| Am | americium |
| amp/m$^2$ | amperes per square meter |
| CEARP | Comprehensive Environmental Assessment and Response Program |
| COC | constituent(s) of concern |
| COPEC | constituent(s) of potential ecological concern |
| cpm | count(s) per minute |
| Cs | cesium |
| EPA | U.S. Environmental Protection Agency |
| ER | Environmental Restoration |
| famsl | ft above mean sea level |
| fbgl | ft below ground level |
| fbgs | ft below ground surface |
| ft | foot (feet) |
| GM | Geiger-Mueller |
| MDA | minimum detectable activity |
| mg/kg | milligram(s) per kilogram |
| mrem/hr | millirem(s) per hour |
| NFA | No Further Action |
| pCi/g | picocurie(s) per gram |
| Pu | plutonium |
| PVC | polyvinyl chloride |
| QA | quality assurance |
| QC | quality control |
| RCRA | Resource Conservation and Recovery Act |
| RFA | RCRA Facility Assessment |
| SNL/NM | Sandia National Laboratories/New Mexico |
| SVOC | semivolatile organic compound(s) |
| TA-II | Technical Area II |
| U | uranium |
| UCP | Uranium Calibration Pit |
| VCM | Voluntary Corrective Measure |
| VOC | volatile organic compound(s) |

# 1.0 INTRODUCTION

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a risk-based No Further Action (NFA) for Environmental Restoration (ER) Site 44, the Uranium Calibration Pits (UCP) (ER Site 44a) and the Decontamination Area (ER Site 44b), Operable Unit 1303. ER Site 44 has been divided into two separate areas based on historical operations and potential constituents of concern (COC). This proposal provides a description, history, evaluation of relevant evidence, and rationale for the NFA decision for ER Site 44.

## 1.1 Description of Environmental Restoration Site 44

The UCPs were used to test and calibrate down-hole radiometric logging tools for the National Uranium Resource Evaluation Program. The UCPs were located in the western portion of Technical Area II (TA-II), west of Building 906 (Figure 1-1). The Decontamination Area was used to decontaminate weapons components and related test materials from the Nevada Test Site. The Decontamination Area, less than 0.1 acre in area, is located on the west side of Building 906, near the central portion of TA-II (Figure 1-1).

The regional aquifer in the vicinity of ER Site 44 is within the upper unit of the Santa Fe Group. The depth to the regional aquifer in the nearest monitor well to ER Site 44 (TA2-NW1-595) is approximately 520 feet (ft) below ground surface (fbgs) or 4,889.3 ft above mean sea level (famsl). TA2-NW1-595 has a total depth of 598 fbgs, with screens from 535 to 555 fbgs and 585 to 595 fbgs. A shallow water-bearing zone also exists in the vicinity of ER Site 44. The depth to the shallow zone in the vicinity of ER Site 44 ranges from approximately 267 to 320 fbgs (5,081 to 4,889 famsl). Monitor wells TA2-SW1-325, TA2-NW1-320, WYO-2, TA2-W-19, and TA2-W-01 are located in the vicinity of ER Site 44 and are screened in the shallow water-bearing zone.

The area is essentially flat, with a gentle slope to the west of approximately 4 percent. Tijeras Arroyo, the largest drainage feature at SNL/NM, is located immediately southeast of TA-II. The surface geology at ER Site 44 consists of unconsolidated alluvial and colluvial deposits derived from the Sandia and Manzanita Mountains. These deposits consist of sediments ranging from clay to gravel derived from the granitic rocks of the Sandia Mountains and greenstone, limestone, and quartzite derived from the Manzanita Mountains (SNL/NM 1996).

Surficial deposits are underlain by the upper unit of the Santa Fe Group. Hawley and Haase (1992) estimate that in this area, the piedmont-slope alluvium may be up to 100 ft thick, and the upper Santa Fe unit is approximately 1,200 ft thick.

The piedmont-slope alluvium, which was deposited by the ancestral Tijeras Arroyo, is generally coarse-grained sand and gravel. The upper Santa Fe unit was deposited from 5 to 1 million years ago and consists of coarse- to fine-grained fluvial deposits from the ancestral Rio Grande that intertongue with coarse-grained alluvial-fan/piedmont-veneer facies, which extend westward from the Sandia and Manzanita Mountains. ER Site 44 is near the easternmost limit of the ancestral Rio Grande deposits (Hawley and Haase 1992).

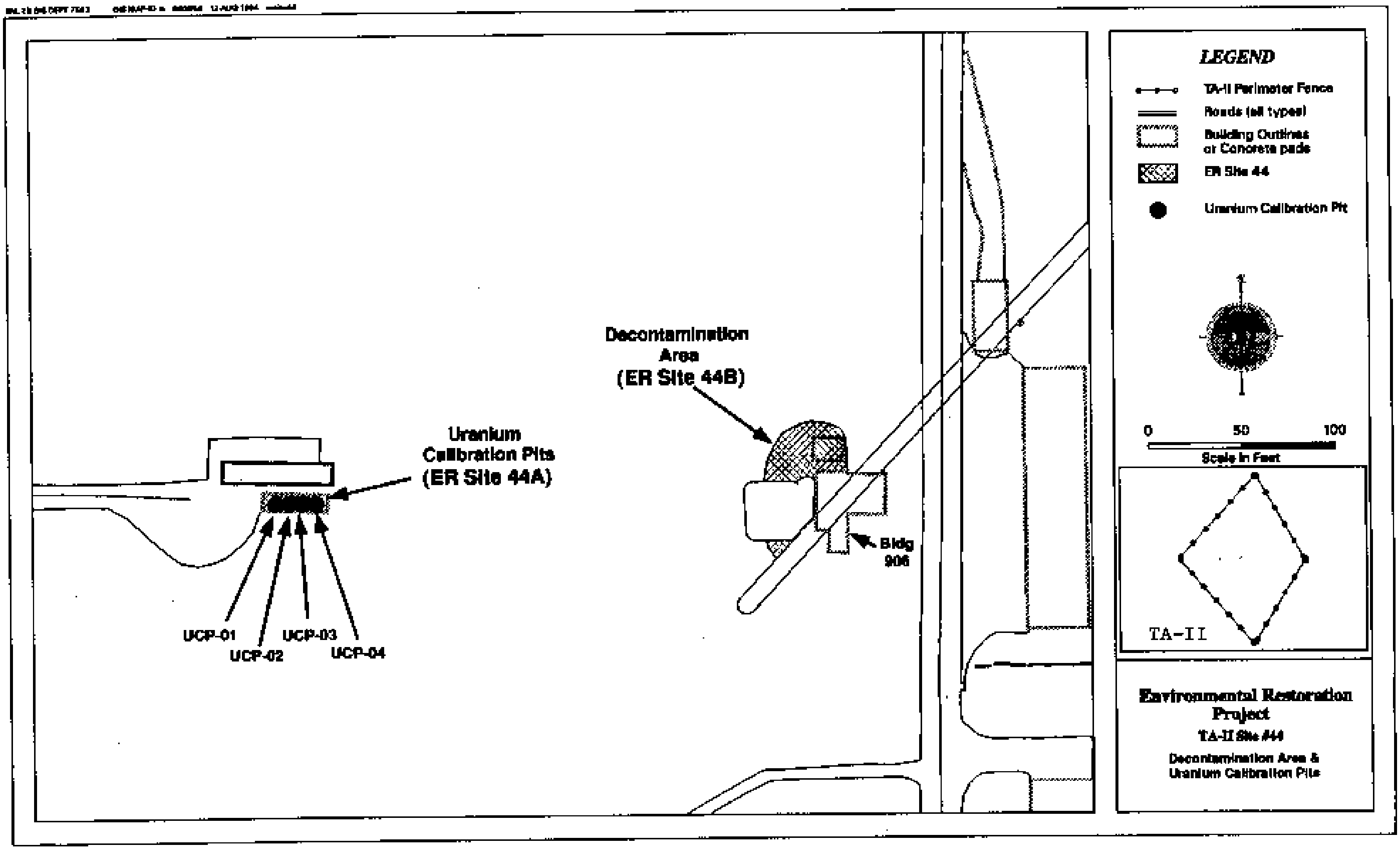


Figure 1-1. ER Sites 44A and 44B Location Map

Several rift-bounding faults are located east of ER Site 44. The nearest is the Sandia fault-zone, characterized by north-trending, west-dipping normal faults. The westernmost fault is located approximately 1.2 miles east of the site (Hawley and Haase 1992). The Sandia fault-zone merges with the Tijeras fault-zone and the Hubbell Springs fault near the southern edge of Kirtland Air Force Base. These faults are discussed in the 1995 Site-Wide Hydrogeologic Characterization Project Annual Report (SNL/NM 1996) as well as in Hawley and Haase (1992).

## 1.2 No Further Action Basis

Review and analysis of all relevant data for ER Sites 44a and 44b indicate that concentrations of COCs at these site are less than the applicable risk assessment action levels (Section 6.0). Thus, ER Sites 44a and 44b are being proposed for an NFA decision based on confirmatory sampling data demonstrating that COCs that may have been released from this site into the environment pose an acceptable level of risk under current and projected future land use, per NFA Criterion 5 of the ER Document of Understanding (NMED April 1996).

# 2.0 HISTORY OF ENVIRONMENTAL RESTORATION SITE 44

This section discusses the historical operations, previous audits, inspections, and findings at ER Sites 44a and 44b.

## 2.1 ER Site 44a

### 2.1.1 Historical Operations at ER Site 44a

The UCPs consisted of four pits that were constructed in 1978. Very limited information exists about the geophysical testing conducted at the UCPs. Initial information was based on employee interviews (Haines et al. 1991). No testing reports, "As Built," or other engineering drawings are known to exist for the UCPs. Construction details and pit contents discussed below were verified during the Voluntary Corrective Measure (VCM).

Construction Details of the UCPs

From west to east, the four UCPs were numbered sequentially 1 through 4 (Figure 2-1). The distance between the centers of adjacent pits was approximately 6 ft. The four UCPs were constructed by excavating 4-ft diameter pits to 8 fbgs. A small borehole (about 4.5 inches in diameter) subsequently was drilled in the center of each pit. Boreholes at UCPs 1, 2, and 3 were drilled to approximately 19, 14, and 18 fbgs, respectively. The UCP 4 borehole was drilled to an approximate depth of 206 ft. Four-inch diameter polyvinyl chloride (PVC) pipes were installed into the UCPs 2, 3, and 4 boreholes, and a four-inch diameter steel pipe was installed in the UCP 1 borehole. The pipes were not grouted in place. Four 4-ft diameter by 8-ft long concrete culverts (i.e., hollow concrete pipe) subsequently were lowered by a crane into each of the open pits. After the culverts were in place, a 6-inch thick concrete plug was poured at the bases of UCPs 1, 3, and 4. UCP 2 did not have a concrete plug base. Although the cement plugs were poured in the culverts, it was assumed that leakage could have occurred between the plug and the culvert. A circular steel plate was placed upon, but was not sealed to, the top of each UCP and served as a pit cover.

Historical Use of the Uranium Calibration Pits

Although basic construction details were similar for the four UCPs, the pits were used for different uranium (U) calibration operations. Reported materials and processes used at each pit are described below. No information was revealed during the employee interviews, audits, surveys, or VCM that indicated material had been removed from the UCPs during the period of operation.

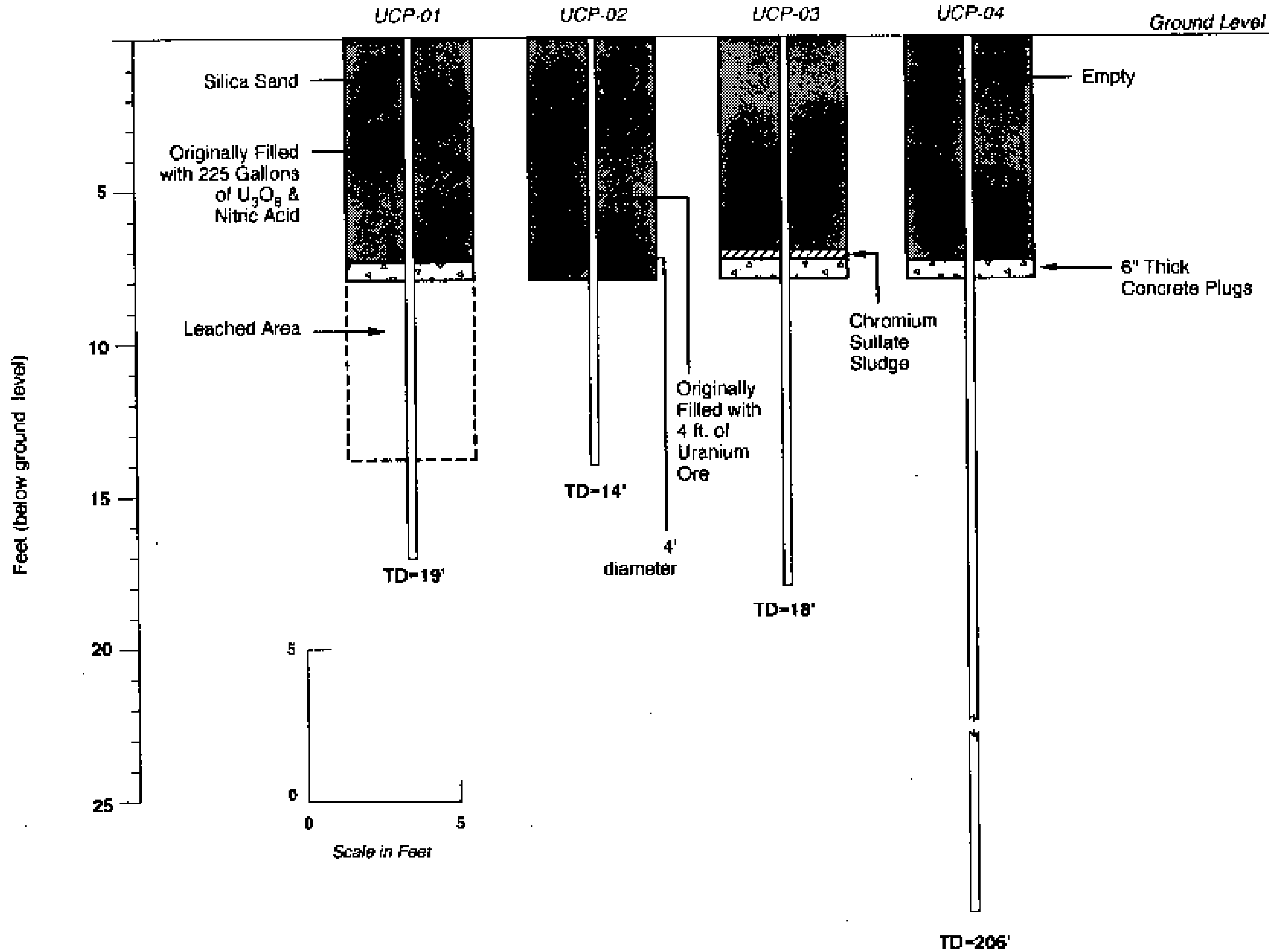


**Figure 2-1**
**Schematic Cross Section of the Four Uranium Calibration Pits (ER Site 44a)**

Uranium Calibration Pit 1

UCP 1 (Figure 2-1) was used to simulate a water-saturated, uranium (U)-bearing sand. The pit was filled with silica sand, which then was saturated with a solution of uranyl nitrate. Ten to twenty pounds of U oxide were dissolved with a minimal amount of nitric acid, which subsequently was diluted with distilled water to form the uranyl nitrate solution. The total volume of uranyl nitrate solution was approximately 225 gallons. After the UCP was filled, the solution inadvertently migrated into the soil beneath the pit, where it precipitated in the alkaline soil.

Uranium Calibration Pit 2

UCP 2 (Figure 2-1) had a plastic sheeting bottom and was filled with 4 ft of U ore from the Jackpile mine near Grants, New Mexico. Another plastic sheet was placed on top of the ore and 4 ft of clean fill was placed above the sheeting.

Uranium Calibration Pit 3

UCP 3 (Figure 2-1) was lined with a waterproof neoprene fabric liner with sealed seams that extended to the rim of the concrete culvert. The pit was filled with a solution of chromium sulfate.

Uranium Calibration Pit 4

No solutions or other material were placed into UCP 4 (Figure 2-1). It was used only for background calibrations.

### 2.1.2 Previous Audits, Inspections, and Findings

In 1987, a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) was performed for the entire SNL/NM installation (EPA 1987). At that time, ER Site 44, the UCPs and the Decontamination Area, were identified as solid waste management unit #130 and were described as having the potential for release of hazardous waste or constituents. A more comprehensive assessment was performed under Phase 1 of the Comprehensive Environmental Assessment and Response Program (CEARP) (DOE 1987), during which the UCPs and Decontamination Area were assessed and, again, were found to require additional investigation. The scope of the Phase 1 assessment included a literature and records search, interviews with current and former employees, and, in some cases, visual site inspections. No samples and only limited background data were collected during both the RFA and CEARP Phase 1 assessment.

## 2.2 ER Site 44b

### 2.2.1 Historical Operations at ER Site 44b

The Decontamination Area was used from approximately the late 1960s until the mid-1970s. Weapons components and related test materials from the Nevada Test Site reportedly were decontaminated outside Building 906. These materials may have contained metals and radionuclides. Decontamination (washing off contaminated material with a hose) was conducted on the ground surface.

### 2.2.2 Previous Audits, Inspections, and Findings

Section 2.1.2 discusses the previous audits, inspections, and findings for ER Site 44b.

# 3.0 EVALUATION OF RELEVANT EVIDENCE

## 3.1 ER Site 44a

### 3.1.1 Unit Characteristics and Operating Practices

The characteristics and best available knowledge concerning the operating practices are described in Section 2.1.1. No activities have occurred at ER Site 44a since those described in Section 2.1.1.

### 3.1.2 Results of SNL/NM ER Project Sampling/Surveys

Several rounds of sampling have occurred at ER Site 44a, including surveys for gamma contamination and organic vapors. Radiation levels above background were found in UCP 1 and UCP 2. No organic vapors were detected at the site. The results of the surveys are summarized in Table 3-1 and in the sections below.

#### *3.1.2.1 Prior Investigations of ER Site 44a*

The following sources of information were used to evaluate ER Site 44a:

- Interviews of SNL/NM personnel
- Photographs and field notes collected at the site by SNL/NM ER staff
- Radiation survey of ER Site 44a, December 1991
- Organic vapor survey of UCPs, December 1991
- Radiation survey of UCPs, January 1994
- ER Site 44a VCM, Summer 1994.

### 3.1.3 Radiological Surveys of ER Site 44a

Two radiation surveys have been performed at ER Site 44a. The results of the surveys are summarized in Table 3-1. On December 5 and 6, 1991, a radiation survey was performed at the UCPs. The survey was performed using a Bicron 2000 gamma detector at waist height, and an ASP-1 survey meter with a HP-260 Geiger-Mueller (GM) pancake probe at ground level for beta-gamma detection. The objectives of the survey were to determine both the general area gamma radiation levels and to try to detect the presence of surface contamination. The

Table 3-1
Summary of ER Project Radiological Surveys at ER Site 44a

| Date | Survey/Sample for | Location | Value | Background/ Action Level |
|---|---|---|---|---|
| 12/91 | Gamma surface survey | General area | 0.02 to 0.03 mrem/hr | Values within background |
| | | | 80 to 140 cpm | Values within background |
| | Gamma survey (near surface survey) | UCP 1 pipe | Near 0 activity | Value within background |
| | | UCP 2 pipe | 0.5 mrem/hr | Above background |
| | | UCP 3 pipe | 0.25 mrem/hr | Above background |
| | | UCP 4 pipe | Near 0 activity | Value within background |
| 1/94 | Gamma survey (downhole survey) | UCP 1 pipe | > Background from 8 ft (74,614 cpm) to 14 ft (21,088 cpm) | 14,400 cpm (background) |
| | | UCP 2 pipe | > Background from just below ground surface (25,544 cpm) to 11 ft (23,088 cpm) | |
| | | UCP 3 pipe | < Background | |
| | | UCP 4 pipe | < Background | |

cpm - Counts per minute.
ft - feet.
mrem/hr - Millirem(s) per hour.
pCi/g - Picocuries per gram.

radiation levels varied from approximately 0.02 to 0.03 millirem per hour (mrem/hr). Surface readings varied from approximately 80 to 140 counts per minute (cpm), well within the range of area background. Several swipe surveys also were performed on the ground, and personnel were monitored for contamination. No elevated readings were indicated.

During the field survey, a hand-held radiation detector was lowered into the pipes at each UCP. Readings up to 0.5 and 0.25 mrem/hr were detected at UCP 2 and 3, respectively, at depths of approximately 3 fbgl. No activities were detected at UCPs 1 and 4.

In January 1994, a second radiation survey was conducted at the four UCPs. The survey was conducted using a downhole PRS-1 sodium iodide gamma probe. Readings were taken approximately every foot in each of the four UCPs. Results of this survey indicate:

- UCP 1 had readings above background (14,400 cpm) from about 8 fbgl (74,614 cpm) to 19 fbgl (21,088 cpm), the total depth of the PVC.
- UCP 2 had elevated readings from 25,544 cpm near the ground surface to 23,088 cpm at 11 fbgl, i.e., 3 ft below the culvert. Total depth of the PVC was approximately 14 fbgl.
- UCP 3 had no elevated readings above background. Total depth of the PVC was approximately 18 fbgl.
- UCP 4 had no elevated readings above background down to the total surveyed depth of 50 fbgl. Total depth of the PVC was approximately 206 fbgl.

### 3.1.4 Organic Survey of ER Site 44a

On December 5 and 6, 1991, an organic vapor survey was performed at the UCPs. The organic vapor survey was conducted using an HNu photoionization detector, held at waist height, field calibrated to read equivalent benzene concentration. No readings were detected.

### 3.1.5 VCM Sampling

The UCPs were remediated in June 1994 as a VCM. The following describes the activities performed at each of the four UCPs as part of the VCM. A summary of VCM sampling is included in Table 3-2.

The UCP culverts were removed one at a time, after interior contents were removed, by excavating approximately 8 fbgl with a backhoe and then removing the culvert with a crane. Radiological soil screening was performed in the excavation from 4 fbgl to total depth. After removing each culvert, radiological screening of the soil below the culvert was performed. If radiological levels were at background or below, a confirmatory soil sample was taken. If radiological levels were above background, contaminated soil was removed until background levels were achieved, and then a sample was taken at the bottom of the excavation.

Table 3-2
Summary of VCM Sampling at ER Site 44a

| Date | Survey/Sample for | Location | MDA (pCi/g) | Value | Background/ Action Level |
|---|---|---|---|---|---|
| 6/94 | Gamma spectrometry and isotopic uranium (following VCM) | UCP 1 | 0.018 | U-238 at 26 pCi/g<br>U-235 at 1.1 pCi/g<br>U-234 at 26 pCi/g | Preliminary risk-based action level 28.6 pci/g |
| | | UCP 2 | 0.057 | U-238 at 2 pCi/g | |
| | | UCP 3 | 0.022 | U-238 at 0.93 pCi/g | |
| | | UCP 4 | 0.028 | U-238 at 0.77 pCi/g | |
| | Chromium analysis | UCP 3 | 1.0 | Chromium at 3.2 mg/kg | Proposed Subpart S Action Level 400 mg/kg |

MDA - Minimum detectable activity.
mg/kg - Milligrams per kilogram.
pCi/g - Picocuries per gram.

The following variations from the above description are noted. At UCP 1, background levels were never obtained in the excavation. Contaminated soil was found for approximately 6 ft beneath the bottom of the concrete plug. Excavation of contaminated soil was ceased when gamma spectrometry results for U were below the preliminary risk-based action level of 28.6 picocuries per gram (pCi/g). Confirmatory soil samples also were taken from the backfill as the excavation was restored to surface grade.

The residual chromate sulfate solution (discussed in Section 2.1.1 above) in UCP 3 was pumped out in May 1994 as the first phase of the VCM. The liner was also removed at this time. Vermiculite was added to the UCP to absorb a minute amount of solution remaining on the bottom of the culvert.

Confirmatory Soil Samples

Confirmatory soil samples were collected and analyzed by gamma spectrometry for isotopic U at the bottom of each UCP culvert after it was removed unless radioactively contaminated soil was present. Radioactively contaminated soil was defined as having activities above background levels determined by field screening. If contaminated soil was present below the culvert, the soil was removed and a confirmatory soil sample was taken at the bottom of the excavation. A confirmatory sample was also taken from the backfill material as the excavation was returned to surface grade. In addition to the radiological analyses, a sample was taken for chromium below UCP 3.

Confirmatory soil samples analyzed by gamma spectroscopy indicate that U-238 was at or below 2 pCi/g in all samples except for the sample collected below UCP 1 (Table 3-2). The reported concentration in the sample collected from the bottom of the excavation below UCP 1 was 26 pCi/g. The chromium concentration from the sample collected below UCP 3 was 3.2 milligrams per kilogram (mg/kg.

#### 3.1.5.1 *Quality Assurance/Quality Control Summary*

Three sets of quality assurance (QA)/quality control (QC) samples were analyzed as part of the VCM soil sampling program at ER Site 44a. A reagent blank and two laboratory control samples were analyzed with four soil samples sent to an off-site laboratory in June 1994. These QA/QC samples were analyzed for the same constituents (isotopic U) as the soil samples. The reagent blank results were 0.0 pCi/g U-235, 0.086 pCi/g U-233/234, and 0.11 pCi/g U-238. The sample results for these isotopes were significantly higher than the blank results. Results for the spiked laboratory control samples agreed with the known values.

A laboratory control sample and a laboratory control duplicate sample were analyzed in conjunction with a soil sample from ER Site 44a sent to an off-site laboratory in June 1994. These QA/QC samples were analyzed for the same constituents (metals) as the soil sample. The results for the laboratory control sample analyses fell within the required level of precision.

A reagent blank and two laboratory control samples were analyzed with four soil samples sent to an off-site laboratory in July 1994. These QA/QC samples were analyzed for similar radionuclide constituents as the soil samples. The reagent blank results were 0.0 pCi/g U-235, 0.033 pCi/g U-233/234, and 0.014 pCi/g U-238. The sample results for these isotopes were significantly higher than the blank results. Results for the spiked laboratory control samples agreed with the known values.

## 3.2 ER Site 44b

### 3.2.1 Unit Characteristics and Operating Practices

The characteristics and operating practices are described in Section 2.2.1. No activities have occurred at ER Site 44b since those described in Section 2.2.1.

### 3.2.2 Results of SNL/NM ER Project Sampling/Surveys

Several rounds of sampling have occurred in the area, including analyses for volatile organic compounds (VOC), semivolatile organic compounds (SVOC), metals, and radionuclides. No VOCs or SVOCs were detected during an organic vapor survey or a soil vapor investigation. Metals were detected below U.S. Environmental Protection Agency (EPA) action levels and/or below sitewide background soil levels. Radionuclides, with the exception of cesium (Cs)-137, all were detected below sitewide background soil levels or were nondetectable. The results of the surveys are summarized in Tables 3-3 and 3-4 and in the sections below.

Table 3-3
ER Project Radiological Sampling/Surveys at ER Site 44b

| Date | Survey/Sampled for | Location | Value | Background |
|---|---|---|---|---|
| 12/91 | Gamma surface contamination | General area | 20 to 30 µrem/hr | Values within background |
| | | | 80 to 140 cpm | Values within background |
| 3/94 | Gamma contamination | Vicinity of Building 906. (Values from three areas that exceeded background are given.) | 13 to 36 µrem/hr<br>130 to 550 cpm | 12 µrem/hr<br>120 cpm |
| | | | 13 to 15 µrem/hr<br>130 to 160 cpm | |
| | | | 20 µrem/hr<br>250 cpm | |

cpm - Counts per minute.
µrem/hr - Microrems per hour.

Table 3-4
ER Project Organic Vapor Surveys at ER Site 44b

| Date | Survey/Sampled for | Location | Value |
|---|---|---|---|
| 12/91 | Organic vapors | General area | No VOCs or SVOCs detected |
| 11/93 | Organic vapors | Passive soil vapor survey of area | No VOCs or SVOCs detected |

SVOC - Semivolatile organic compounds.
VOC - Volatile organic compounds.

### 3.2.2.1 *Prior Investigations of ER Site 44b*

The following sources of information, presented in chronological order, were used to evaluate ER Site 44b:

- Interviews of SNL/NM personnel
- Photographs and field notes collected at the site by SNL/NM ER staff
- Radiation surveys of ER Site 44b, December 1991 and March 1994

- Organic vapor survey of ER Site 44b, December 1991
- Passive soil vapor survey at ER Site 44b, November 1993
- Geophysical surveys (SNL/NM 1994a, SNL/NM 1994b)
- VCM sampling, November 1996.

### 3.2.3 Radiological Surveys

Two radiation surveys have been performed at ER Site 44b. The results of the surveys are summarized in Table 3-3. On December 5 and 6, 1991, a radiation survey was performed at the Decontamination Area. The radiation survey was performed using a Bicron 2000 gamma detector held at waist height, and an ASP-1 survey meter with a HP-260 GM pancake probe held at ground level for beta-gamma detection. The objectives of the survey were to determine both the general area gamma radiation levels and to try to detect the presence of surface contamination. The radiation levels varied from approximately 20 to 30 microrem per hour (µrem/hr) and surface readings varied from approximately 80 to 140 cpm. Both results were within the range of area background. Several swipe surveys also were performed on the ground, and personnel were monitored for contamination. No elevated readings were indicated.

On March 20, 1994, a surface radiation survey was performed at the Decontamination Area in the immediate vicinity of Building 906 (Figure 1-1). The radiation survey was performed using a gamma scintillometer and a pressurized ionization chamber. A detailed summary of the survey may be found in Section 5.2.1 of "Final Report, Survey and Removal of Radioactive Surface Contamination at Environmental Restoration Sites, Sandia National Laboratories/New Mexico (Draft)" (SNL/NM 1997). Background activities were measured at 120 cpm with the gamma scintillometer and at 12 µrem/hr with the pressurized ionization chamber. Activities above background were measured at three locations within the Decontamination Area. A 60-ft$^2$ area near Building 906 had activities between 130 and 550 cpm and at 13 to 36 µrem/hr. Activities at a 24-ft$^2$ area west of Building 906 ranged between 130 and 160 cpm and 13 to 15 µrem/hr. A 2-ft radius circle located about 5 ft south-southeast of the 24-ft$^2$ area had activities of 250 cpm and 20 µrem/hr. No other activities were measured above background levels in the vicinity of the Decontamination Area.

### 3.2.4 Organic Vapor Surveys

Two organic surveys were performed at the Decontamination Area. The results are summarized in Table 3-4. An organic vapor survey was performed December 5 and 6, 1991, using a HNu photoionization detector held at waist height, field calibrated to read equivalent benzene concentrations. No VOCs were detected. Between November 11 and December 2, 1993, a passive soil vapor survey investigation was conducted in the vicinity of the Decontamination Area. No VOCs or SVOCs were detected.

### 3.2.5 Surface Soil Sampling

As summarized in Table 3-5, soil samples were collected on two occasions in 1994. On February 4 and 11, 1994, surface soil grab samples were collected near the northwest corner of Building 906 (Figure 1-1). Four soil samples were collected on February 4, and an additional four soil samples were collected on February 11. The eight soil samples were analyzed for radioisotopes by gamma spectroscopy, for gross alpha/gross beta radiation, and tritium by liquid scintillation. Tritium was below method detection limits in all of the samples; in addition, no elevated gross alpha or gross beta activities were identified. Cs-137 was the only radioisotope detected significantly above background levels. Cs-137 was detected in three surface soil samples, with activities ranging from 8.97 to 87.7 pCi/g. Background for Cs-137 in soil at the surface is 0.84 pCi/g, based on the 95th percentile. Background for Cs-137 in soil in the subsurface is inferred to be less than the cited detection limit for the analyses (0.084 pCi/g) (IT Corporation 1994).

During April 1994, six surface and six subsurface (2 fbgs) soil samples were collected in areas previously identified as anomalous based on the surface radiation survey and previous surface soil sample results. The 12 soil samples were analyzed for radioisotopes and metals.

All metals detected were below EPA action-level guidelines except for beryllium. Beryllium concentrations ranged from 0.33 to 0.59 mg/kg, compared to an EPA action level of 0.2 mg/kg. However, sitewide background concentrations show an upper tolerance level of 0.80 mg/kg at a 95 percent confidence level. Therefore, beryllium concentrations are presumed to represent background levels and are not indicative of contamination.

Radionuclides, with the exception of Cs-137, all were detected below background levels when the 2 standard deviation error was considered. Cs-137 concentrations ranged from less than 0.057 to 43 pCi/g, with an approximate mean of 6 pCi/g.

### 3.2.6 Geophysical Surveys

A STOLS™ survey was performed over the Decontamination Area in December 1993 (SNL/NM 1994a). Two large (>10 amperes per square meter [amp/m²]), two medium (6 to 10 amp/m²), and three small (0 to 5 amp/m²) magnetic anomalies along with 19 point locations were identified in the Decontamination Area. The anomalies have been attributed to buried utilities or fencelines (SNL/NM 1994a). One pipe is associated with the sanitary septic line of Building 907. The point locations are products of ferromagnetic surface trash and concentrations of ferromagnetic soil and rock.

An electromagnetic survey was performed during the period of December 6, 1993, through February 24, 1994. The Decontamination Area was surveyed as part of the Phase II Survey Design using the EM-31 survey instrument (SNL/NM 1994b). The survey identified the seepage pit west of Building 906. Various buried utility lines also were identified.

Table 3-5
ER Project Surface Soil Sampling at ER Site 44b

| Date | Survey/Sampled for | Location | Value | Background |
|---|---|---|---|---|
| 2/94 | Soils analyzed for radioisotopes, gross alpha/beta, and tritium | Vicinity of Building 906 | Cs-137[a] at 8.97 to 87.7 pCi/g | 0.836 pCi/g |
| | | | No elevated gross/alpha values | Values within background |
| | | | Tritium < detection limit | NA |
| 4/94 | Soils analyzed for radioisotopes and metals | Areas of previous "hits" | Cs-137[a] at >0.057 to 43 pCi/g | Values above background |
| | | | Beryllium[b] 0.33 to 0.59 mg/kg | Background is 0.80 mg/kg<br>EPA action level is 0.2 mg/kg |

[a]Only radioisotope detected significantly above background levels.
[b]Only metal detected above EPA action level.
cpm - Counts per minute.
NA - Nondetect.
mg/kg - Milligrams per kilogram.
pCi/g - Picocuries per gram.

### 3.2.7 VCM Sampling at ER Site 44b

VCM activities were conducted at ER Site 44b during November 1996. Cleanup activities included radiation scanning to verify anomalies identified in 1994, removal of fragments and/or soil until readings were less than 1.3 times site-specific background levels, and post-cleanup (verification) soil sampling for gamma spectroscopy analysis. After the removal of radiologically contaminated soils, three surface samples were collected from areas exhibiting the highest residual radioactivity remaining in the soil based on field measurements. The location of radiation survey anomalies and soil sampling locations are shown on Figure 3-1. The maximum levels for Cs-134 and Cs-137 were as follows: Cs-134 not detected and Cs-137 detected at 0.77 pCi/g.

#### *3.2.7.1 Quality Assurance/Quality Control Summary*

The surface soil samples were analyzed by gamma spectroscopy by the SNL/NM Radiation Protection Measurements Department in accordance with laboratory and quality assurance procedures. The procedures are listed in Section 3.2.2 of "Final Report, Survey and Removal of Radioactive Surface Contamination at Environmental Restoration Sites, Sandia National

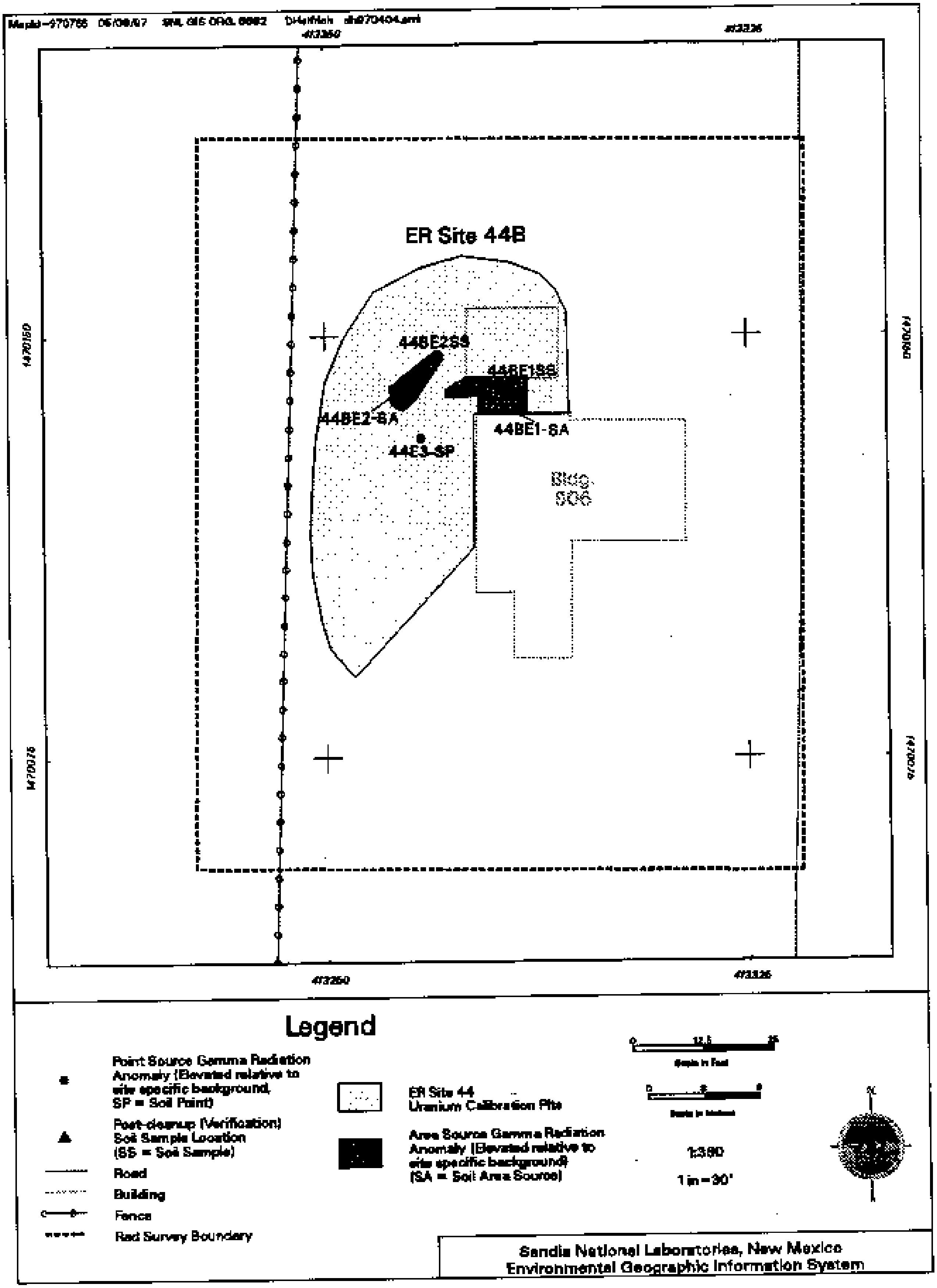


**Figure 3-1 Phase I Radiation Survey Anomalies and VCM Surface Soil Sampling Locations at ER Site 44B**

Laboratories/New Mexico (Draft)" (SNL/NM 1997). Copies of the procedures are provided in Appendix D of the document.

## 3.3 Gaps in Information

Information about the geophysical testing at ER Site 44a was largely gathered by employee interviews. Construction details and pit contents at ER Site 44a were revealed during the VCM. Information obtained during the various survey and sampling events at ER Sites 44a and 44b were used, along with other available information, to help identify the most likely COCs that might be found at the sites. Analytical data from soil samples collected at the sites (Sections 3.1.5 and 3.2.6) and subsequent risk assessment (Section 3.4) are sufficient to determine whether significant releases of COCs occurred at the site.

## 3.4 Risk Evaluation for ER Sites 44a and 44b

Human Health and Ecological Risk Assessment Reports were prepared for ER Sites 44a and 44b and are included in Sections 6.1 and 6.2, respectively.

### 3.4.1 Human Health Risk Assessment

ER Sites 44a and 44b have been recommended for industrial land-use (DOE and USAF 1995). A complete discussion of the risk assessment process, results, and uncertainties is provided in Sections 6.1 and 6.2. Due to the presence of several metals and radionuclides in concentrations and activities greater than background levels, it was necessary to perform a human health risk assessment analysis for the site. Besides metals, any radionuclide compounds either detected above background levels and/or minimum detectable activities were included in this assessment. The risk assessment process provides a quantitative evaluation of the potential adverse human health effects caused by constituents in the site's soil. The Risk Assessment Report presents calculations of the Hazard Index and excess cancer risk for both an industrial land-use and residential land-use setting. The excess cancer risk from nonradioactive COCs and the radioactive COCs is not additive (EPA 1989). The results of the ER Sites 44a and 44b risk assessments are summarized below.

The only nonradiological COC at ER Site 44a was chromium. The maximum chromium concentration was less than the proposed Subpart S action level, and therefore chromium was eliminated from further consideration in the risk assessment during this screening phase. The incremental total effective dose equivalent for radionuclides for an industrial land-use setting at ER Site 44a is 0.06 mrem/yr, which is well below the standard dose limit of 15 mrem/yr (40CFR196 1994). The incremental excess cancer risk for radionuclides is $2 \times 10^{-6}$ for the industrial land-use scenario, which is much less than risk values calculated due to naturally occurring radiation and from intakes considered background concentration values.

The Hazard Index calculated for ER Site 44b nonradiological COCs is 0.0 for an industrial land-use setting, which is less than the numerical standard of 1.0 suggested by risk assessment guidance (EPA 1989). Incremental risk is determined by subtracting risk associated with background from potential nonradiological COC risk. The incremental Hazard Index is 0.0. The excess cancer risk for ER Site 44b nonradiological COCs is $1 \times 10^{-6}$ for an industrial land-use setting, which is at the low end of the suggested range of acceptable risk of $10^{-4}$ to $10^{-6}$ (EPA 1989). The incremental excess cancer risk for ER Site 44b is $3 \times 10^{-6}$. A radiological risk assessment was not performed because no radioactive COCs existed in excess of background concentrations.

The residential land-use scenarios for these sites are provided only for comparison in the Risk Assessment Reports (Sections 6.1 and 6.2). The reports conclude that ER Sites 44a and 44b do not have significant potential to affect human health under an industrial land-use scenario.

### 3.4.2 Ecological Risk Assessment

No ecological receptors are predicted for ER Site 44a due to the depth of COCs in the subsurface soil (>5 fbgs).

Potential risks were indicated for two of the three ecological receptors at ER Site 44b; however, the use of the maximum measured soil concentration or one-half the maximum detection limit to evaluate risk provided a conservative exposure scenario for the risk assessment and may not reflect actual site conditions. Detection limits, at half value, were used to evaluate risk for silver. Maximum measured soil concentrations for chromium (total), mercury, and zinc exceeded their respective plant benchmark concentrations. Although risk was predicted to plants exposed to chromium at this site, the maximum total chromium concentration is actually less than the background value of 12.8 mg/kg. No potential risk was predicted for the deer mouse from nonradioactive constituents of potential ecological concern (COPEC). Mercury was the only COPEC concentration that resulted in an HQ greater than 1.0 for the burrowing owl. Because the home range of the owl is more than 20 times the size of the site, the true risk for the burrowing owl due to mercury from Site 44b is insignificant. Based on these results, silver and chromium can be justified for elimination as a COPECs at ER Site 44b; The incremental risk resulted from zinc, subtracting the background, would produce an HQ of 0.2. However, it is very likely that the other risk results are driven by conservatisms in data analysis. HQs based on 95 percent upper confidence limits of the mean will likely be lower and still be a conservative estimate of site conditions. Overall ecological risks associated with ER Site 44b are expected to be low.

## 4.0 RATIONALE FOR NO FURTHER ACTION DECISION

Based on field investigation data and the human health risk assessment analysis, an NFA is recommended for ER Site 44a for the reasons given below.

- VCM sampling results
  - Reported chromium concentration from the sample collected from below UCP 3 is far below the proposed Subpart S Action Level
  - All U concentrations at the UCPs, both soil collected from below the removed culverts and in the backfill soil, also were below risk-based action levels.
- No VOCs were detected during the field screening program or were reportedly used at the site.
- No COCs (particularly metals or radionuclides) were present in concentrations considered hazardous to human health for an industrial land-use scenario.

An NFA for ER Site 44b is recommended for the following reasons:

- After the VCM, which removed point sources with elevated Cs-137, all radionuclide samples were reported at concentrations below background levels.
- All metals were reported below site-specific background concentrations.
- No VOCs or SVOCs were detected during the field screening program.
- No COCs (particularly metals and radionuclides) were present in concentrations considered hazardous to human health for an industrial land-use scenario.

Based on the evidence provided above, ER Sites 44a and 44b are proposed for an NFA based on Criterion 5 of the Document of Understanding (NMED April 1996).

# 5.0 REFERENCES


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U.S. Environmental Protection Agency (EPA), 1987. "RCRA Facility Assessment Report of Solid Waste Management Units at Sandia National Laboratories," Region 6, U.S. Environmental Protection Agency, Albuquerque, New Mexico.

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## 6.0 ANNEXES

6.1 ER Site 44a: Risk Assessment Report

6.2 ER Site 44b: Risk Assessment Report

## Section 6.1
## ER Site 44a: Risk Assessment Report

# ER SITE 44a: RISK ASSESSMENT ANALYSIS

## I. Site Description and History

The Uranium Calibration Pits (UCP), Environmental Restoration (ER) Site 44a at Sandia National Laboratories/New Mexico (SNL/NM), were active between 1978 and 1984. The UCPs were located in the western portion of Technical Area (TA)-II west of Building 906. The site consisted of four pits that were managed by the U.S. Department of Energy (DOE). The UCPs were used to test and calibrate down-hole radiometric logging tools for the National Uranium Resource Evaluation Program. The pits were constructed in 1978 and were used until 1984. The site has been inactive since 1984.

From west to east, the four UCPs were numbered sequentially 1 through 4. UCP 1 was used to simulate a water-saturated, uranium-bearing sand. The pit was filled with silica sand, which then was saturated with a solution of uranyl nitrate. UCP 2 contained uranium ore with an estimated grade of 0.1 percent uranium oxide or "yellowcake." UCP 3 was filled with a solution of chromium sulfate. UCP 4 was used only for background calibrations and never contained any anthropogenic materials. Therefore, constituents of concern (COC) included uranium and chromium.

## II. Human Health Risk Assessment Analysis

Risk assessment of this site includes a number of steps, which culminate in a quantitative evaluation of the potential adverse human health effects caused by constituents located at the site. The steps to be discussed include:

| | |
|---|---|
| Step 1. | Site data are described that provide information on the potential COCs, as well as the relevant physical characteristics and properties of the site. |
| Step 2. | Potential pathways by which a representative population might be exposed to the COCs are identified. |
| Step 3. | The potential intake of these COCs by the representative population is calculated using a tiered approach. The tiered approach includes screening steps, followed by potential intake calculations and a discussion or evaluation of the uncertainty in those calculations. Potential intake calculations are also applied to background screening data. |
| Step 4. | Data are described on the potential toxicity and cancer effects from exposure to the COCs and associated background constituents and subsequent intake. |
| Step 5. | Potential toxicity effects (specified as a Hazard Index) and cancer risks are calculated for nonradiological COCs and background. For radiological COCs, the incremental total effective dose equivalent (TEDE) and incremental estimated cancer risk are calculated by subtracting applicable background concentrations directly from maximum on-site contaminant values. This background subtraction only occurs when a radiological COC occurs as contamination and exists as a natural background radionuclide. |
| Step 6. | These values are compared with guidelines established by the U.S. Environmental Protection Agency (EPA) and the DOE to determine whether further evaluation, and potential site clean-up, is required. Nonradiological COC risk values are also compared to background risk so that an incremental risk may be calculated. |
| Step 7. | Uncertainties in the previous steps are discussed. |

## II.1 Step 1. Site Data

Site history and characterization activities are used to identify potential COCs. The identification of COCs and the sampling to determine the concentration levels of those COCs across the site are described in the ER Site 44a No Further Action Proposal. In order to provide conservatism in this risk assessment, the calculation uses only the maximum concentration value of each COC determined for the entire site. Chemicals that are essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, were not included in this risk assessment (EPA 1989). Both radioactive and nonradioactive COCs are evaluated. The only nonradioactive COC is chromium; the only radioactive COC is uranium.

## II.2 Step 2. Pathway Identification

ER Site 44a has been designated with a future land-use scenario of industrial (DOE and U.S. Air Force [USAF] 1996) (see Appendix 1 for default exposure pathways and parameters). Because of the location and the characteristics of the potential contaminants, the primary pathway for human exposure is considered to be soil ingestion for chemical COCs and radon inhalation and soil ingestion is included for exposure from radiological contaminants. The inhalation pathway for chemicals and radionuclides is included because of the potential to inhale dust and volatiles. No contamination at depth was suspected, and therefore no water pathways to the groundwater are considered. Depth to groundwater at Site 44a is approximately 320 feet below ground surface. Because of the lack of surface water or other significant mechanisms for dermal contact, the dermal exposure pathway is considered not to be significant. No intake routes through plant, meat, or milk ingestion are considered appropriate for the industrial land-use scenario. However, plant uptake is considered for the residential land-use scenario.

**PATHWAY IDENTIFICATION**

| Chemical Constituents | Radionuclide Constituents |
|---|---|
| Soil ingestion | Soil ingestion |
| Inhalation (dust) | Inhalation (dust and volatiles) |
| Plant uptake (residential only) | Plant uptake (residential only) |
| | Direct gamma |

## II.3 Steps 3-5. Calculation of Hazard Indices and Cancer Risks

Steps 3 through 5 are discussed in this section. These steps include the discussion of the tiered approach in eliminating potential COCs from further consideration in the risk assessment process and the calculation of intakes from all identified exposure pathways, the discussion of the toxicity information, and the calculation of the hazard indices and cancer risks.

The risks from the COCs at ER Site 44a were evaluated using a tiered approach. First, the maximum concentrations of COCs were compared to the SNL/NM background screening level for this area (IT Corporation 1996), as modified during verbal discussion with representatives of New Mexico Environment Department (NMED).

The maximum concentration of each COC was used in order to provide a conservative estimate of the associated risk. If any nonradiological COC was above the SNL/NM background screening levels, all nonradiological COCs were considered in further risk assessment analyses.

For radiological COCs that exceeded the SNL/NM background screening levels, background values were subtracted from the individual maximum radionuclide concentrations. Those that did not exceed these background levels were not carried any further in the risk assessment. This approach is consistent with DOE orders. Radioactive COCs that did not have a background value and were detected above the analytical minimum detectable activity were carried through the risk assessment at their maximum levels. This step is performed (rather than carry the below-background radioactive COCs through the risk assessment and then perform a background risk assessment to determine incremental TEDE and estimated cancer risk) to prevent the "masking" of radiological contamination that may occur if on-site background radiological COCs exist in concentrations far enough below the assigned background level. When this "masking" occurs, the final incremental TEDE and estimated cancer risk are reduced and, therefore, provide a nonconservative estimate of the potential impact on an on-site receptor. This approach is also consistent with the regulatory approach (40 CFR Part 196 1994), which sets a TEDE limit to the on-site receptor in excess of background. The resultant radioactive COCs remaining after this step are referred to as background-adjusted radioactive COCs.

Second, if any nonradiological COC failed the initial screening step, the maximum concentration for each nonradiological COC was compared with pertinent action level calculated using methods and equations promulgated in the proposed Resource Conservation and Recovery Act Subpart S (40 CFR Part 264 1990) and Risk Assessment Guidance for Superfund (RAGS) (EPA 1989) documentation. If there are ten or fewer COCs and each has a maximum concentration less than one-tenth of its action level, then the site would be judged to pose no significant health hazard to humans. If there are more than ten COCs, the Subpart S screening procedure was skipped.

Third, hazard indices and risk due to carcinogenic effects were calculated using reasonable maximum exposure (RME) methods and equations promulgated in RAGS (EPA 1989). The combined effects of all nonradiological COCs in the soils were calculated. The combined effects of the nonradiological COCs at their respective upper tolerance limit (UTL) or 95th percentile background concentrations in the soil were also calculated. For toxic compounds, the combined effects were calculated by summing the individual hazard quotients for each compound into a total Hazard Index. This Hazard Index is compared to the recommended standard of 1. For potentially carcinogenic compounds, the individual risks were summed. The total risk was compared to the recommended acceptable risk range of $10^{-4}$ to $10^{-6}$. For the radioactive COCs, the incremental TEDE was calculated and the corresponding incremental cancer risk estimated using DOE's RESRAD computer code.

## II.3.1 Comparison to Background and Action Levels

The only nonradioactive ER Site 44a COC is listed in Table 1, and radioactive COCs are listed in Table 2. Both tables show the associated 95th percentile or UTL background levels (IT Corporation 1996), as modified during verbal discussions with representatives of NMED. The SNL/NM background levels have not yet been approved by the EPA or the NMED but are the result of a comprehensive study of joint SNL/NM and USAF data from the Kirtland Air Force Base (KAFB). The values shown in Tables 1 and 2 supersede the background values described in an interim background study report (IT Corporation 1994).

Table 1 is limited to the sole nonradiological COC, chromium. The chromium concentration was considered to be chromium VI (most conservative). Because there was no SNL/NM background 95th percentile or UTL for chromium VI, the site fails the background screening criteria, and the proposed Subpart S action level screening procedure was performed.

Table 3 shows chromium compared to the proposed Subpart S action level for soil. The table compares the maximum concentration value to the proposed Subpart S action level. This methodology was guidance given to SNL/NM from the EPA (EPA 1996a). This is the second screening process in the tiered risk assessment approach. Chromium was less than the proposed Subpart S action level. Thus, the site passes the proposed Subpart S screening criteria, and a Hazard Index value and cancer risk value does not have to be calculated for chromium.

**Table 1**
**Chromium concentration at ER Site 44a and Comparison to the Background Screening Value**

| COC name | Maximum concentration (mg/kg) | SNL/NM 95th % or UTL Level (mg/kg) | Is maximum COC concentration less than or equal to the applicable SNL/NM background screening value? |
|---|---|---|---|
| Chromium, total* | 3.2 | NC | No |

NC - not calculated
*total chromium assumed to be chromium VI (most conservative)

**Table 2**
**Radioactive COCs at ER Site 44a and Comparison to the Background Screening Values**

| COC name | Maximum concentration (pCi/g) | SNL/NM 95th % or UTL Level (pCi/g) | Is maximum COC concentration less than or equal to the applicable SNL/NM background screening value? |
|---|---|---|---|
| U-238 | 26 | 1.3 | No |
| U-235 | 1.1 | 0.18 | No |
| U-233/234 | 26 | 1.6 | No |

**Table 3**
**Comparison of ER Site 44a Nonradioactive COC Concentrations to Proposed Subpart S Action Levels**

| COC name | Maximum concentration (mg/kg) | Proposed Subpart S Action Level (mg/kg) | Is individual contaminant less than the Action Level? |
|---|---|---|---|
| Chromium, total* | 3.2 | 400 | Yes |

* total chromium assumed to be chromium VI (most conservative)

Radioactive contamination does not have predetermined action levels analogous to proposed Subpart S, and therefore this step in the screening process is not performed for radionuclides.

### II.3.2 Identification of Toxicological Parameters

Table 4 shows the radiological COCs that have been retained in the risk assessment and the values for the toxicological information available for those COCs. Dose conversion factors (DCF) used in determining the incremental TEDE values for the individual pathways were the default values provided in the RESRAD computer code as developed in the following:

- For ingestion and inhalation, DCFs are taken from Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* (EPA 1988).

- The DCFs for surface contamination (contamination on the surface of the site) were taken from DOE/EH-0070, *External Dose-Rate Conversion Factors for Calculation of Dose to the Public* (DOE 1988).

- The DCFs for volume contamination (exposure to contamination deeper than the immediate surface of the site) were calculated using the methods discussed in, *Dose-Rate Conversion Factors for External Exposure to Photon Emitters in Soil* (Health Physics 28:193-205) (Kocher 1983), and ANL/EAIS-8, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil* (Yu et al. 1993a).

### II.3.3 Exposure Assessment and Risk Characterization

Section II.3.3.1 describes the exposure assessment for this risk assessment. Section II.3.3.2 provides the risk characterization, including the incremental TEDE and incremental estimated cancer risk, for the background-adjusted radiological COCs for industrial and residential land uses.

**Table 4**
**Radiological Toxicological Parameter Values for ER Site 44a COCs**

| COC name | $SF_{ev}$ (g/pCi-yr) | $SF_o$ (1/pCi) | $SF_{inh}$ (1/pCi) | Cancer Class^ |
|---|---|---|---|---|
| U-238 | $5.7 \times 10^{-8}$ | $6.2 \times 10^{-11}$ | $1.2 \times 10^{-8}$ | A |
| U-235 | $2.7 \times 10^{-7}$ | $4.7 \times 10^{-11}$ | $1.3 \times 10^{-8}$ | A |
| U-233/234 | $2.1 \times 10^{-11}$ | $4.4 \times 10^{-11}$ | $1.4 \times 10^{-8}$ | A |

$SF_{ev}$ - external volume exposure slope factor (risk/yr per pCi/g)
$SF_o$ - oral (ingestion) slope factor (risk/pCi)
$SF_{inh}$ - inhalation slope factor (risk/pCi)
^ EPA weight-of-evidence classification system for carcinogenicity:

A - human carcinogen
B1 - probable human carcinogen. Limited human data are available
B2 - probable human carcinogen. Indicates sufficient evidence in animals and inadequate or no evidence in humans.
C - possible human carcinogen
D - not classifiable as to human carcinogenicity
E - evidence of noncarcinogenicity for humans

### II.3.3.1 Exposure Assessment

For radionuclides, the coded equations provided in the RESRAD computer code were used to estimate the excess dose and cancer risk for the individual exposure pathways. Further discussion of this process is provided in Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0 (Yu et al. 1993b).

Although the designated land-use scenario is industrial for this site, the risk and TEDE values for a residential land-use scenario are also presented. These residential risk and TEDE values are presented only to provide perspective on the potential for risk to human health under the more restrictive land-use scenario.

### II.3.3.2 Risk Characterization

For the radioactive COCs, contribution from the direct gamma exposure pathway is included, as well as inhalation and soil ingestion. For residential land use, the plant ingestion pathway is included. The incremental TEDE for industrial land-use is 0.06 millirems per year (mrem/yr), and the estimated excess cancer risk is $2 \times 10^{-6}$. For residential land-use, the incremental TEDE is 0.22 mrem/yr, and the estimated excess cancer risk is $3 \times 10^{-6}$.

## II.4 Step 6. Comparison of Risk Values to Numerical Guidelines.

The risk assessment analyses considered the evaluation of the potential for adverse health effects for both an industrial land-use scenario, which is the designated land-use scenario for this site, and a residential land-use scenario.

For the industrial land-use scenario, the calculated incremental TEDE is 0.06 mrem/yr. In accordance with proposed EPA guidance, the standard being utilized is an incremental TEDE of 15 mrem/yr (40 CFR Part 196 1994) for the probable land-use scenario (industrial in this case); the calculated dose value for ER Site 44a for an industrial land-use is well below this standard. The estimated excess cancer risk is $2 \times 10^{-6}$.

For the residential land-use scenario, the incremental TEDE is 0.22 mrem/yr. In accordance with proposed EPA guidance, the standard being utilized is an incremental TEDE of 75 mrem/yr (40 CFR Part 196 1994) for a complete loss of institutional controls (residential land-use in this case); the calculated dose values for ER Site 44a for the residential land-use scenario is well below this standard. It should also be noted that, consistent with the proposed guidance (40 CFR Part 196 1994), ER Site 44a should be eligible for unrestricted radiological release, as the residential scenario resulted in an incremental TEDE to the on-site receptor of less than 15 mrem/yr. The associated estimated excess cancer risk is $3 \times 10^{-6}$.

## II.5 Step 7 Uncertainty Discussion

The voluntary corrective measures (VCM) at ER Site 44a involved the removal of four concrete culverts. After removing each culvert, radiological screening of the soil below the culvert was performed. If radiological levels were at background or below, a confirmatory soil sample was taken. If radiological levels were above background, contaminated soil was removed until background levels were achieved, and then a sample was taken at the bottom of the excavation. The sampling method was defined in the VCM Plan and was deemed sufficient to characterize the site. The contaminants of concern were chromium and isotopic uranium. The chromium was analyzed by EPA Method 6010, and the isotopic uranium was analyzed by alpha spectroscopy.

Three sets of quality assurance/quality control (QA/QC) samples were analyzed as part of the VCM soil sampling program at Site 44a. A reagent blank and two laboratory control samples were included with four soil samples sent to an off-site laboratory in June 1994. These QA/QC samples were analyzed for the same constituents (isotopic uranium) as the soil samples. The reagent blank results were 0.0 picocuries per gram (pCi/g) for uranium (U)-235, 0.086 pCi/g for U-233/234, and 0.11 pCi/g for U-238. The sample results for these isotopes were significantly higher than the blank results. The spiked laboratory control samples agreed with the known values.

Laboratory duplicate control and single control samples were analyzed in conjunction with a soil sample from Site 44a sent to an off-site laboratory in June 1994. These QA/QC samples were analyzed for the same constituents (metals) as the soil sample. The results of the laboratory control sample analyses fell within the required level of precision.

A reagent blank and two laboratory control samples were included with four soil samples sent to an off-site laboratory in July 1994. These QA/QC samples were analyzed for similar radionuclide constituents as the soil samples. The reagent blank results were 0.0 pCi/g for U-235, 0.033 pCi/g for U-233/234, and 0.014 pCi/g for U-238. The sample results for these isotopes were significantly higher than the blank results. The spiked laboratory control samples agreed with the known values.

All soil samples were sent off site to a Contract Laboratory Program (CLP) laboratory for analysis. The data provided by the CLP laboratory are considered definitive data suitable for use in a risk assessment analysis.

The conclusion from the risk assessment analysis is that the potential effects caused by the nonradiological COC (chromium) on human health are within the proposed Subpart S screening criteria and therefore are not considered to pose significant risk to human health. Risk calculations were not performed for chromium since it was eliminated during the proposed Subpart S screening procedure.

For the radiological COCs, the conclusion from the risk assessment is that the potential effects on human health, for the industrial and residential land-use scenarios, are well within the proposed standard (40 CFR Part 196 1994) and are a small fraction of the estimated 290 mrem/yr received due to natural background (NCRP 1989).

Because of the location, history of the site, and the future land-use (DOE and USAF 1995), there is low uncertainty in the land-use scenario and the potentially affected populations that were considered in making the risk assessment analysis. Because the COCs are found in subsurface soils and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values, which means that the parameter values used in the calculations were conservative and that the calculated intakes are likely overestimates. Maximum measured values of the concentrations of the COCs were used to provide conservative results.

The radiological incremental TEDE is a very small fraction of estimated background TEDE for both the industrial and residential land-use scenarios, and both are well within proposed guidelines (40 CFR Part 196 1994). The overall uncertainty in all of the steps in the risk assessment process is considered insignificant with respect to the conclusion reached.

## II.6 Summary

ER Site 44a, the UCPs, had relatively minor contamination (after remediation) consisting of chromium and radioactive compounds. Because of the location of the site on KAFB, the designated industrial land-use scenario (DOE and USAF 1995), and the nature of the contamination, the potential exposure pathways identified for this site included soil ingestion and dust inhalation for chemical constituents and soil ingestion, dust and volatile inhalation, and direct gamma exposure for radionuclides. Plant uptake was included as an exposure pathway for the residential land-use scenario. This site is designated for industrial land-use (DOE and USAF 1995); the residential land-use scenario is provided for perspective only.

The maximum chromium concentration was less than the proposed Subpart S action level and therefore was eliminated from further consideration in the risk assessment during this screening phase.

The incremental TEDE and corresponding estimated cancer risk from the radioactive components are much less than EPA guidance values; the estimated incremental TEDE is 0.06 mrem/yr for the industrial land-use scenario. This value is much less than the numerical guidance of 15 mrem/yr in draft EPA guidance. The corresponding estimated excess cancer risk value is $2 \times 10^{-6}$ for the industrial land-use scenario.

The uncertainties associated with the calculations are considered small relative to the conservativeness of the risk assessment analysis. It is therefore concluded that this site does not have significant potential to affect human health under an industrial land-use scenario.

## III. Ecological Risk Assessment

### III.1 Introduction

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPEC) at SNL/NM ER Site 44a. The ecological risk assessment process performed for this site is a screening level assessment that follows the methodology presented in IT Corporation (1997) and SNL/NM (1997). The methodology was based on screening level guidance presented by the EPA (EPA 1992, 1996b, 1997) and by Wentsel et al. (1996) and is consistent with a phased approach. This assessment utilizes conservatism in the estimation of ecological risks; however, ecological relevance and professional judgment are also incorporated as recommended by EPA (1996b) and Wentsel et al. (1996) to ensure that the predicted exposures of selected ecological receptors reasonably reflect those expected to occur at the site.

### III.2 Ecological Pathways

ER Site 44a is part of Operable Unit 1303 and is located in TA-II. In general, the land within TA-II has been developed in its entirety (IT Corporation 1995). Essentially no suitable habitat (i.e., biological resources) remain in this area to sustain a viable ecological pathway between COPECs in surface and subsurface soil and plants and wildlife.

Chemical contamination of soils at this site has been assessed at soil depths greater than 5 feet. As stated in the protocol for performing ecological risk assessments for the SNL/NM ER Program (IT Corporation 1997), COCs in soil are considered to be bioavailable to a depth of 5 feet. This judgment is based on low rainfall of this habitat. Based on information on root depths and burrowing depths of species common to the grassland habitat at SNL/NM (e.g., Davis 1966, Reynolds and Wakkinen 1987, Reynolds and Fraley 1989), rooting and burrowing in this habitat is expected to be concentrated in the first few feet of the soil profile. If the receptors cannot be exposed to a contaminant, the exposure pathway for that contaminant can be characterized as incomplete (EPA 1996b, Wentsel et al. 1996). Chemical contaminants at ER Site 44a are not accessible to ecological receptors, and therefore, complete ecological pathways do not exist at this site.

### III.3 Constituents of Potential Ecological Concern

Because no complete ecological pathways exist at this site, none of the COCs are considered COPECs.

### III.4 Risk Characterization

Due to the depth of the COCs in the subsurface soils, no complete ecological pathways exist at this site. The consequent lack of a cause-and-effect relationship leads to the conclusion no ecological risks are associated with the COCs at this site (Wentsel et al. 1996).

### III.5 Uncertainties

The identification of 5 feet as the probable limit of rooting and burrowing depth at SNL/NM is founded on professional judgment based on the observed habitat conditions and information on rooting and burrowing depths from similar habitats and species. Although the possibility of contact with COCs at this depth cannot be completely ruled out, the rarity of such an event, coupled with the small size and disturbed nature of the site, will make it inconsequential to the health and integrity of the ecosystem at large.

### III.6 Summary

No ecological receptors are predicted for ER Site 44a due to the depth of COCs in the subsurface soil (>5 ft below ground).

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# APPENDIX 1.

**Sandia National Laboratories Environmental Restoration Program**

## EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION

## BACKGROUND

Sandia National Laboratories (SNL) proposes that a default set of exposure routes and associated default parameter values be developed for each future land-use designation being considered for SNL/NM Environmental Restoration (ER) project sites. This default set of exposure scenarios and parameter values would be invoked for risk assessments unless site-specific information suggested other parameter values. Because many SNL/NM ER sites have similar types of contamination and physical settings, SNL believes that the risk assessment analyses at these sites can be similar. A default set of exposure scenarios and parameter values will facilitate the risk assessments and subsequent review.

The default exposure routes and parameter values suggested are those that SNL views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the USEPA Region VI and NMED, SNL proposes that these default exposure routes and parameter values be used in future risk assessments.

At SNL/NM, all Environmental Restoration sites exist within the boundaries of the Kirtland AFB. Approximately 157 potential waste and release sites have been identified where hazardous, radiological, or mixed materials may have been released to the environment. Evaluation and characterization activities have occurred at all of these sites to varying degrees. Among other documents, the SNL/ER draft Environmental Assessment (DOE 1996) presents a summary of the hydrogeology of the sites, the biological resources present and proposed land use scenarios for the SNL/NM ER sites. At this time, all SNL/NM ER sites have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based on a residential land use scenario. All three land use scenarios will be addressed in this document.

The SNL/NM ER project has screened the potential exposure routes and identified default parameter values to be used for calculating potential intake and subsequent hazard index, risk and dose values. EPA (EPA 1989a) provides a summary of exposure routes that could potentially be of significance at a specific waste site. These potential exposure routes consist of:

- Ingestion of contaminated drinking water;
- Ingestion of contaminated soil;
- Ingestion of contaminated fish and shell fish;
- Ingestion of contaminated fruits and vegetables;
- Ingestion of contaminated meat, eggs, and dairy products;
- Ingestion of contaminated surface water while swimming;
- Dermal contact with chemicals in water;
- Dermal contact with chemicals in soil;
- Inhalation of airborne compounds (vapor phase or particulate), and;

- External exposure to penetrating radiation (immersion in contaminated air; immersion in contaminated water and exposure from ground surfaces with photon-emitting radionuclides).

Based on the location of the SNL ER sites and the characteristics of the surface and subsurface at the sites, we have evaluated these potential exposure routes for different land use scenarios to determine which should be considered in risk assessment analyses (the last exposure route is pertinent to radionuclides only). At SNL/NM ER sites, there does not presently occur any consumption of fish, shell fish, fruits, vegetables, meat, eggs, or dairy products that originate on-site. Additionally, no potential for swimming in surface water is present due to the high-desert environmental conditions. As documented in the RESRAD computer code manual (ANL 1993), risks resulting from immersion in contaminated air or water are not significant compared to risks from other radiation exposure routes.

For the industrial and recreational land use scenarios, SNL/NM ER has therefore excluded the following four potential exposure routes from further risk assessment evaluations at any SNL/NM ER site:

- Ingestion of contaminated fish and shell fish;
- Ingestion of contaminated fruits and vegetables;
- Ingestion of contaminated meat, eggs, and dairy products; and
- Ingestion of contaminated surface water while swimming.

That part of the exposure pathway for radionuclides related to immersion in contaminated air or water is also eliminated.

For the residential land-use scenario, we will include ingestion of contaminated fruits and vegetables because of the potential for residential gardening.

Based on this evaluation, for future risk assessments, the exposure routes that will be considered are shown in Table 1. Dermal contact is included as a potential exposure pathway in all land use scenarios. However, the potential for dermal exposure to inorganics is not considered significant and will not be included. In general, the dermal exposure pathway is generally considered to not be significant relative to water ingestion and soil ingestion pathways but will be considered for organic components. Because of the lack of toxicological parameter values for this pathway, the inclusion of this exposure pathway into risk assessment calculations may not be possible and may be part of the uncertainty analysis for a site where dermal contact is potentially applicable.

## EQUATIONS AND DEFAULT PARAMETER VALUES FOR IDENTIFIED EXPOSURE ROUTES

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation may also be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land use scenarios. The general equations for calculating potential intakes via

**Table 1. Exposure Pathways Considered for Various Land Use Scenarios**

| Industrial | Recreational | Residential |
|---|---|---|
| | | |
| Ingestion of contaminated drinking water | Ingestion of contaminated drinking water | Ingestion of contaminated drinking water |
| Ingestion of contaminated soil | Ingestion of contaminated soil | Ingestion of contaminated soil |
| Inhalation of airborne compounds (vapor phase or particulate) | Inhalation of airborne compounds (vapor phase or particulate) | Inhalation of airborne compounds (vapor phase or particulate) |
| Dermal contact | Dermal contact | Dermal contact |
| External exposure to penetrating radiation from ground surfaces | External exposure to penetrating radiation from ground surfaces | Ingestion of fruits and vegetables |
| | | External exposure to penetrating radiation from ground surfaces |

these routes are shown below. The equations are from the Risk Assessment Guidance for Superfund (RAGS): Volume 1 (EPA 1989a and 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL 1993). Also shown are the default values SNL/NM ER suggests for use in Reasonable Maximum Exposure (RME) risk assessment calculations for industrial, recreational, and residential scenarios, based on EPA and other governmental agency guidance. The pathways and values for chemical contaminants are discussed first, followed by those for radionuclide contaminants. RESRAD input parameters that are left as the default values provided with the code are not discussed. Further information relating to these parameters may be found in the RESRAD Manual (ANL 1993).

## Generic Equation for Calculation of Risk Parameter Values

The equation used to calculate the risk parameter values (i.e., Hazard Quotient/Index, excess cancer risk, or radiation total effective dose equivalent [dose]) is similar for all exposure pathways and is given by:

Risk (or Dose) = Intake x Toxicity Effect (either carcinogenic, noncarcinogenic, or radiological)

$$= C \times (CR \times EFD/BW/AT) \times \text{Toxicity Effect} \qquad (1)$$

where

- C = contaminant concentration (site specific);
- CR = contact rate for the exposure pathway;
- EFD = exposure frequency and duration;
- BW = body weight of average exposure individual;
- AT = time over which exposure is averaged.

The total risk/dose (either cancer risk or hazard index) is the sum of the risks/doses for all of the site-specific exposure pathways and contaminants.

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk range of $10^{-4}$ to $10^{-6}$. The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the Hazard Index) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard Hazard Index of unity (1). The evaluation of the health hazard due to radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA 1989a) and the RESRAD Manual (ANL 1993). Table 2 shows the default parameter values suggested for used by SNL at ER sites, based on the selected land use scenario. References are given at the end of the table indicating the source for the chosen parameter values. The intention of SNL is to use default values that are consistent with regulatory guidance and consistent with the RME approach. Therefore, the values chosen will, in general, provide a conservative estimate of the actual risk parameter. These parameter values are suggested for use for the various exposure pathways based on the assumption that a particular site has no unusual characteristics that contradict the default assumptions. For sites for which the assumptions are not valid, the parameter values will be modified and documented.

Summary

SNL proposes the described default exposure routes and parameter values for use in risk assessments at sites that have an industrial, recreational or residential future land-use scenario. There are no current residential land-use designations at SNL ER sites, but this scenario has been requested to be considered by the NMED. For sites designated as industrial or recreational land-use, SNL will provide risk parameter values based on a residential land-use scenario to indicate the effects of data uncertainty on risk value calculations or in order to potentially mitigate the need for institutional controls or restrictions on Sandia ER sites. The parameter values are based on EPA guidance and supplemented by information from other government sources. The values are generally consistent with those proposed by Los Alamos National Laboratory, with a few minor variations. If these exposure routes and parameters are acceptable, SNL will use them in risk assessments for all sites where the assumptions are consistent with site-specific conditions. All deviations will be documented.

**Table 2. Default Parameter Values for Various Land Use Scenarios**

| Parameter | Industrial | Recreational | Residential |
|---|---|---|---|
| **General Exposure Parameters** | | | |
| Exposure frequency (d/y) | *** | *** | *** |
| Exposure duration (y) | 30[a,b] | 30[a,b] | 30[a,b] |
| Body weight (kg) | 70[a,b] | 56[a,b] | 70 adult[a,b]<br>15 child |
| Averaging Time (days)<br>for carcinogenic compounds<br>(=70 y x 365 d/y)<br>for noncarcinogenic compounds<br>(=ED x 365 d/y) | 25550[a]<br><br>10950 | 25550[a]<br><br>10950 | 25550[a]<br><br>10950 |
| | | | |
| **Soil Ingestion Pathway** | | | |
| Ingestion rate | 100 mg/d[c] | 6.24 g/y[c] | 114 mg-y/kg-d[a] |
| | | | |
| **Inhalation Pathway** | | | |
| Inhalation rate ($m^3$/yr) | 5000[a,b] | 146[c] | 5475[a,b,d] |
| Volatilization factor ($m^3$/kg) | chemical specific | chemical specific | chemical specific |
| Particulate emission factor ($m^3$/kg) | 1.32E9[a] | 1.32E9[a] | 1.32E9[a] |
| | | | |
| **Water Ingestion Pathway** | | | |
| Ingestion rate (L/d) | 2[a,b] | 2[a,b] | 2[a,b] |
| | | | |
| **Food Ingestion Pathway** | | | |
| Ingestion rate (kg/yr) | NA | NA | 138[b,d] |
| Fraction ingested | NA | NA | 0.25[b,d] |
| | | | |
| **Dermal Pathway** | | | |
| Surface area in water ($m^2$) | 2[b,e] | 2[b,e] | 2[b,e] |
| Surface area in soil ($m^2$) | 0.53[b,e] | 0.53[b,e] | 0.53[b,e] |
| Permeability coefficient | chemical specific | chemical specific | chemical specific |

*** The exposure frequencies for the land use scenarios are often integrated into the overall contact rate for specific exposure pathways. When not included, the exposure frequency for the industrial land use scenario is 8 h/d for 250 d/y; for the recreational land use, a value of 2 hr/wk for 52 wk/y is used (EPA 1989b); for a residential land use, all contact rates are given per day for 350 d/y.

[a] RAGS, Vol 1, Part B (EPA 1991).

[b] Exposure Factors Handbook (EPA 1989b)

[c] EPA Region VI guidance.

[d] For radionuclides, RESRAD (ANL 1993) is used for human health risk calculations; default parameters are consistent with RESRAD guidance.

[e] Dermal Exposure Assessment (EPA 1992).

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## Section 6.2
## ER Site 44b: Risk Assessment Report

# ER SITE 44b: RISK ASSESSMENT ANALYSIS

## I. Site Description and History

The Decontamination Area, Environmental Restoration (ER) Site 44b at Sandia National Laboratories/New Mexico (SNL/NM), was used for a number of years until the mid-1970s. The area was used to decontaminate materials shipped from the Nevada Test Site (NTS). The Decontamination Area is located on the west side of Building 906, near the central portion of Technical Area (TA)-II.

Weapons components and related test materials from the NTS reportedly were decontaminated outside Building 906. These materials may have contained metals and radionuclides. Decontamination (washing off contaminated material with a hose) probably was conducted on the ground surface. No other information has been found regarding past activities conducted at the Decontamination Area. Contaminants of concern (COC) include metals and radionuclides.

## II. Human Health Risk Assessment Analysis

Risk assessment of this site includes a number of steps, which culminate in a quantitative evaluation of the potential adverse human health effects caused by constituents located at the site. The steps to be discussed include:

| | |
|---|---|
| Step 1. | Site data are described that provide information on the potential COCs, as well as the relevant physical characteristics and properties of the site. |
| Step 2. | Potential pathways by which a representative population might be exposed to the COCs are identified. |
| Step 3. | The potential intake of these COCs by the representative population is calculated using a tiered approach. The tiered approach includes screening steps, followed by potential intake calculations and a discussion or evaluation of the uncertainty in those calculations. Potential intake calculations are also applied to background screening data. |
| Step 4. | Data are described on the potential toxicity and cancer effects from exposure to the COCs and associated background constituents and subsequent intake. |
| Step 5. | Potential toxicity effects (specified as a Hazard Index) and cancer risks are calculated for nonradiological COCs and background. For radiological COCs, the incremental total effective dose equivalent (TEDE) and incremental estimated cancer risk are calculated by subtracting applicable background concentrations directly from maximum on-site contaminant values. This background subtraction only occurs when a radiological COC occurs as contamination and exists as a natural background radionuclide. |
| Step 6. | These values are compared with guidelines established by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) to determine whether further evaluation, and potential site clean-up, is required. Nonradiological COC risk values are also compared to background risk so that an incremental risk may be calculated. |
| Step 7. | Uncertainties in the previous steps are discussed. |

## II.1 Step 1. Site Data

Site history and characterization activities are used to identify potential COCs. The identification of COCs and the sampling to determine the concentration levels of those COCs across the site are described in the ER Site 44b No Further Action Proposal. In order to provide conservatism in this risk assessment, the calculation uses only the maximum concentration value of each COC determined for the entire site. Maximum concentrations of nonradiological COCs reported from subsurface and surface samples were combined into a single table to provide conservative risk calculations. All radiological COCs were found to be on the surface so only surface background was used. Minimum upper tolerance limits (UTL) or 95th percentiles, as appropriate, were selected to provide the background screen in Table 1 and to be used to calculate risk attributable to background for Table 6. Chemicals that are essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, were not included in this risk assessment (EPA 1989). Both radioactive and nonradioactive COCs are evaluated. The nonradioactive COCs evaluated are metals.

## II.2 Step 2. Pathway Identification

ER Site 44b has been designated with a future land-use scenario of industrial (DOE and USAF 1995) (see Appendix 1 for default exposure pathways and parameters). Because of the location and the characteristics of the potential contaminants, the primary pathway for human exposure is considered to be soil ingestion for chemical COCs and direct gamma exposure for radiological contaminants. The inhalation pathway for both chemicals is included because of the potential to inhale dust and volatiles. Soil ingestion is included for radiological COCs. No contamination at depth was suspected, and therefore no water pathways to the groundwater are considered. Depth to groundwater at Site 44b is approximately 320 feet below ground surface. Because of the lack of surface water or other significant mechanisms for dermal contact, the dermal exposure pathway is considered not to be significant. No intake routes through plant, meat, or milk ingestion are considered appropriate for the industrial land-use scenario. However, plant uptake is considered for the residential land-use scenario.

**PATHWAY IDENTIFICATION**

| Chemical Constituents | Radionuclide Constituents |
|---|---|
| Soil ingestion | Soil ingestion |
| Inhalation (dust) | Inhalation (dust and volatiles) |
| Plant uptake (Residential only) | Plant uptake (residential only) |
| | Direct gamma |

## II.3 Steps 3-5. Calculation of Hazard Indices and Cancer Risks

Steps 3 through 5 are discussed in this section. These steps include the discussion of the tiered approach in eliminating potential COCs from further consideration in the risk assessment process and the calculation of intakes from all identified exposure pathways, the discussion of the toxicity information, and the calculation of the hazard indices and cancer risks.

**Table 1**
**Nonradioactive COCs at ER Site 44b and Comparison to the Background Screening Values**

| COC name | Maximum concentration (mg/kg) | SNL/NM 95th % or UTL Level (mg/kg) | Is maximum COC concentration less than or equal to the applicable SNL/NM background screening value? |
|---|---|---|---|
| Barium | 122 | 200 | Yes |
| Beryllium | 0.59 | 0.80 | Yes |
| Cadmium | 0.7 | <1^ | NA |
| Chromium, total* | 9.3 | NC | NA |
| Lead | 25.7 | 11.2 | No |
| Mercury | 0.33 | <0.1^ | No |
| Nickel | 11.4 | 25.4 | Yes |
| Silver | 0.5** | <1^ | NA |
| Zinc | 84.1 | 76 | No |

NC - not calculated
NA - not applicable
*total chromium assumed to be chromium VI (most conservative)
^ uncertainty due to detection limits
** concentrations are assumed to be one-half of the detection limit

The risks from the COCs at ER Site 44b were evaluated using a tiered approach. First, the maximum concentrations of COCs were compared to the SNL/NM background screening levels for this area (IT Corporation 1996), as modified during verbal discussion with representatives of New Mexico Environment Department (NMED). If a SNL/NM-specific screening level was not available for a constituent, then a background value was obtained, when possible, from the U.S. Geological Survey (USGS) National Uranium Resource Evaluation program (USGS 1994).

The maximum concentration of each COC was used in order to provide a conservative estimate of the associated risk. If any nonradiological COCs were above either the SNL/NM background screening levels or the USGS background value, all nonradiological COCs were considered in further risk assessment analyses.

For radiological COCs that exceeded the SNL/NM background screening levels, background values were subtracted from the individual maximum radionuclide concentrations. Those that did not exceed these background levels were not carried any further in the risk assessment. This approach is consistent with DOE orders. Radioactive COCs that did not have a background value and were detected above the analytical minimum detectable activity were carried through the risk assessment at their maximum levels. This step is performed (rather than carry the below-background radioactive COCs through the risk assessment and then perform a background risk assessment to determine incremental TEDE and estimated cancer risk) to prevent the "masking" of radiological contamination that may occur if on-site background radiological COCs exist in concentrations far enough below the assigned background level. When this "masking" occurs, the final incremental TEDE and estimated cancer risk are reduced and, therefore, provide a non-conservative estimate of the potential impact on an on-site receptor. This approach is also consistent with the regulatory approach (40 CFR Part 196 1994), which sets a TEDE limit to the on-site receptor in excess of background. The resultant radioactive COCs remaining after this step are referred to as background-adjusted radioactive COCs.

Second, if any nonradiological COC failed the initial screening step, the maximum concentration for each nonradiological COC was compared with the pertinent action level calculated using methods and equations promulgated in the proposed Resource Conservation and Recovery Act (RCRA) Subpart S (40 CFR Part 264 1990) and Risk Assessment Guidance for Superfund (RAGS) (EPA 1989) documentation. If there are ten or fewer COCs and each has a maximum concentration less than one-tenth of its action level, then the site would be judged to pose no significant health hazard to humans. If there are more than ten COCs, the Subpart S screening procedure was skipped.

Third, hazard indices and risk due to carcinogenic effects were calculated using reasonable maximum exposure (RME) methods and equations promulgated in RAGS (EPA 1989). The combined effects of all nonradiological COCs in the soils were calculated. The combined effects of the nonradiological COCs at their respective UTL or 95th percentile background concentrations in the soil were also calculated. For toxic compounds, the combined effects were calculated by summing the individual hazard quotients for each compound into a total Hazard Index. This Hazard Index is compared to the recommended guideline of 1. For potentially carcinogenic compounds, the individual risks were summed. The total risk was compared to the recommended acceptable risk range of $10^{-4}$ to $10^{-6}$. For the radioactive COCs, the incremental TEDE was calculated and the corresponding incremental cancer risk estimated using DOE's RESRAD computer code.

## II.3.1 Comparison to Background and Action Levels

Nonradioactive ER Site 44b COCs are listed in Table 1, and radioactive COCs are listed in Table 2. Both tables show the associated 95th percentile or UTL background levels (IT Corporation 1996), as modified during verbal discussion with representatives of NMED.

The SNL/NM background levels have not yet been approved by the EPA or the NMED but are the result of a comprehensive study of joint SNL/NM and U.S. Air Force data from the Kirtland Air Force Base (KAFB). The values shown in Tables 1 and 2 supersede the background values described in an interim background study report (IT Corporation 1994).

Several compounds have maximum measured values greater than background screening levels. Therefore, all nonradiological COCs were retained for further analysis with the exception of lead. The maximum concentration value for lead is 25.7 milligrams per kilogram (mg/kg). The EPA intentionally does not provide any toxicological data on lead, and therefore no risk parameter values can be calculated. However, EPA guidance for the screening value for lead for an industrial land-use scenario is 2,000 mg/kg (EPA 1996a); for a residential land-use scenario, the EPA screening guidance value is 400 mg/kg (EPA 1994). The maximum concentration value for lead at this site is less than both of those screening values, and therefore lead is eliminated from further consideration in this risk assessment. For the

**Table 2**
**Radioactive COCs at ER Site 44b and Comparison to the Background Screening Values**

| COC name | Maximum concentration (pCi/g) | SNL/NM 95th % or UTL Level (pCi/g) | Is maximum COC concentration less than or equal to the applicable SNL/NM background screening value? |
|---|---|---|---|
| U-238 | 1.1 | 1.3 | Yes |
| U-235 | ND | 0.18 | Yes |
| U-234 | ND | 1.6 | Yes |
| Th-232 | 1.0 | 1.54 | Yes |
| Ra-228 | 1.0 | 1.33 | Yes |
| Cs-137 | 0.77 | 0.84 | Yes |

NC - Not calculated.
ND - Not detected.

radiological COCs no maximum measured value exceeded the background screening levels and, therefore, radionuclides were carried no further in the risk assessment.

Because several nonradiological COCs had concentrations greater than their respective SNL/NM background 95th percentiles or UTLs, the site fails the background screening criterion, and all nonradiological COCs proceed to the proposed Subpart S action level screening procedure.

Table 3 shows the nonradioactive COCs compared to the proposed Subpart S action level for soils. The table compares the maximum concentration values to 1/10 of the proposed Subpart S action level. This methodology was guidance given to SNL/NM from the EPA (EPA 1996b). This is the second screening process in the tiered risk assessment approach. Beryllium had a concentration greater than 1/10 of the proposed Subpart S action level. Because of beryllium, the site fails the proposed Subpart S screening criteria, and a Hazard Index value and cancer risk value must be calculated for all of the nonradioactive COCs.

### II.3.2 Identification of Toxicological Parameters

Table 4 shows the COCs that have been retained in the risk assessment and the values for the toxicological information available for those COCs.

### II.3.3 Exposure Assessment and Risk Characterization

Section II.3.3.1 describes the exposure assessment for this risk assessment. Section II.3.3.2 provides the risk characterization, including the Hazard Index value and the excess cancer risk, for both the potential nonradiological COCs and associated background for industrial and residential land-uses.

**Table 3**
**Comparison of ER Site 44b Nonradioactive COC Concentrations to Proposed Subpart S Action Levels**

| COC name | Maximum concentration (mg/kg) | Proposed Subpart S Action Level (mg/kg) | Is individual contaminant less than 1/10 the Action Level? |
|---|---|---|---|
| Barium | 122 | 6,000 | Yes |
| Beryllium | 0.59 | 0.2 | No |
| Cadmium | 0.7 | 80 | Yes |
| Chromium, total* | 9.3 | 400 | Yes |
| Mercury | 0.33 | 20 | Yes |
| Nickel | 11.4 | 2,000 | Yes |
| Silver | 0.5** | 400 | Yes |
| Zinc | 84.1 | 20,000 | Yes |

* total chromium assumed to be chromium VI (most conservative)
** concentrations are assumed to be one-half of the detection limit

**Table 4**
**Nonradioactive Toxicological Parameter Values for ER Site 44b COCs**

| COC name | $RfD_o$ (mg/kg/d) | $RfD_{inh}$ (mg/kg/d) | Confidence | $SF_o$ (kg-d/mg) | $SF_{inh}$ (kg-d/mg) | Cancer Class ^ |
|---|---|---|---|---|---|---|
| Barium | 0.07 | 0.000143 | M | -- | -- | D |
| Beryllium | 0.005 | -- | L | 4.3 | 8.4 | B2 |
| Cadmium | 0.0005 | 0.0000571 | H | -- | 6.3 | B1 |
| Chromium, total* | 0.005 | -- | L | -- | 42 | A |
| Mercury | 0.0003 | 0.0000857 | M | -- | -- | D |
| Nickel | 0.02 | -- | -- | -- | -- | D |
| Silver | 0.005 | -- | L | -- | -- | D |
| Zinc | 0.3 | -- | M | -- | -- | D |

* total chromium assumed to be chromium VI (most conservative)
$RfD_o$ - oral chronic reference dose in mg/kg-day
$RfD_{inh}$ - Inhalation chronic reference dose in mg/kg-day
Confidence - L = low, M = medium, H = high
Heast - Heast Table from EPA 1996c
$SF_o$ - oral slope factor in $(mg/kg\text{-}day)^{-1}$
$SF_{inh}$ - inhalation slope factor in $(mg/kg\text{-}day)^{-1}$
^ EPA weight-of-evidence classification system for carcinogenicity:
A - human carcinogen
B1 - probable human carcinogen. Limited human data are available
B2 - probable human carcinogen. Indicates sufficient evidence in animals and inadequate or no evidence in humans.
C - possible human carcinogen
D - not classifiable as to human carcinogenicity
E - evidence of noncarcinogenicity for humans
-- information not available

### II.3.3.1 Exposure Assessment

Appendix 1 shows the equations and parameter values used in the calculation of intake values and the subsequent Hazard Index and excess cancer risk values for the individual exposure pathways. The appendix shows the parameters for both industrial and residential land-use scenarios. The equations are based on RAGS (EPA 1989). The parameters are based on information from RAGS (EPA 1989), as well as other EPA guidance documents, and reflect the RME approach advocated by RAGS (EPA 1989).

### II.3.3.2 Risk Characterization

Table 5 shows that for the ER Site 44b nonradioactive COCs, the Hazard Index value is 0.00, and the excess cancer risk is $1 \times 10^{-6}$ for the designated industrial land-use scenario. The numbers presented included exposure from soil ingestion and dust inhalation for the nonradioactive COCs. Table 6 shows that assuming the maximum background concentrations of the ER Site 44b associated nonradiological background constituents, the Hazard Index is 0.00, and the excess cancer risk is $1 \times 10^{-6}$ for the designated industrial land-use scenario.

For the residential land-use scenario, the Hazard Index value increases to 1, and the excess cancer risk is $5 \times 10^{-6}$. The numbers presented included exposure from soil ingestion, dust and volatile inhalation, and plant uptake. Although EPA (1991) generally recommends that inhalation not be included in a residential land-use scenario, this pathway is included because of the potential for soil in Albuquerque, New Mexico, to be eroded and, subsequently, for dust to be present even in predominantly residential areas. Because of the nature of the local soil, other exposure pathways are not considered (see Appendix 1). Table 6 also shows that for the ER Site 44b associated nonradiological background constituents, the Hazard Index increases to 0.2, and the excess cancer risk is $6 \times 10^{-6}$.

## II.4 Step 6. Comparison of Risk Values to Numerical Guidelines.

The risk assessment analyses considered the evaluation of the potential for adverse health effects for both an industrial land-use scenario, which is the designated land-use scenario for this site, and a residential land-use scenario.

For the industrial land-use scenario, the Hazard Index calculated for the nonradioactive COCs is 0.00; this is much less than the numerical guideline of 1 suggested in RAGS (EPA 1989). The excess cancer risk is estimated at $1 \times 10^{-6}$. In RAGS, the EPA suggests that a range of values ($10^{-6}$ to $10^{-4}$) be used as the numerical guideline; the value calculated for this site is at the low end of the suggested acceptable risk range. This risk assessment also determined risks considering background concentrations of the potential nonradiological COCs for both the industrial and residential land-use scenarios. For the industrial land-use scenario, the Hazard Index is 0.00. The excess cancer risk is estimated at $1 \times 10^{-6}$. Incremental risk is determined by subtracting risk associated with background from potential nonradiological COC risk. These numbers are not rounded before the difference is determined and therefore may appear to be inconsistent with numbers presented in tables and discussed within the text. The incremental

**Table 5**
**Nonradioactive Risk Assessment Values for ER Site 44b COCs**

| COC Name | Maximum concentration (mg/kg) | Industrial Land-Use Scenario | | Residential Land-Use Scenario | |
|---|---|---|---|---|---|
| | | Hazard Index | Cancer Risk | Hazard Index | Cancer Risk |
| Barium | 122 | 0.00 | -- | 0.02 | -- |
| Beryllium | 0.59 | 0.00 | 1E-6 | 0.00 | 5E-6 |
| Cadmium | 0.7 | 0.00 | 3E-10 | 0.57 | 4E-10 |
| Chromium, total* | 9.3 | 0.00 | 3E-8 | 0.01 | 4E-8 |
| Mercury | 0.33 | 0.00 | -- | 0.57 | -- |
| Nickel | 11.4 | 0.00 | -- | 0.00 | -- |
| Silver | 0.5** | 0.00 | -- | 0.02 | -- |
| Zinc | 84.1 | 0.00 | -- | 0.15 | -- |
| **TOTAL** | | **0.00** | **1E-6** | **1** | **5E-6** |

* total chromium assumed to be chromium VI (most conservative)
** concentrations are assumed to be one-half of the detection limit
-- information not available

**Table 6**
**Nonradioactive Risk Assessment Values for ER Site 44b Background Constituents**

| Constituent Name | Background concentration (mg/kg) | Industrial Land-Use Scenario | | Residential Land-Use Scenario | |
|---|---|---|---|---|---|
| | | Hazard Index | Cancer Risk | Hazard Index | Cancer Risk |
| Barium | 200 | 0.00 | -- | 0.03 | -- |
| Beryllium | 0.80 | 0.00 | 1E-6 | 0.00 | 6E-6 |
| Cadmium | <1 | -- | -- | -- | -- |
| Chromium, total* | NC | -- | -- | -- | -- |
| Mercury | <0.1 | -- | -- | -- | -- |
| Nickel | 25.4 | 0.00 | -- | 0.00 | -- |
| Silver | <1 | -- | -- | -- | -- |
| Zinc | 76 | 0.00 | -- | 0.14 | -- |
| | | | | | |
| **TOTAL** | | **0.00** | **1E-6** | **0.2** | **6E-6** |

-- information not available
* total chromium assumed to be chromium VI (consistent with Table 5)

Hazard Index is zero and the incremental cancer risk is $3 \times 10^{-8}$ for the industrial land-use scenario. These incremental risk calculations indicate insignificant risk to human health from the COCs considering an industrial land-use scenario.

For the residential land-use scenario, the calculated Hazard Index for the nonradioactive COCs is 1, which is equal to the numerical guidance. The excess cancer risk is estimated at $5 \times 10^{-6}$; this value is within the suggested acceptable risk range. The Hazard Index for associated background for the residential land-use scenario is 0.2. The excess cancer risk is estimated at $6 \times 10^{-6}$. For the residential land-use scenario, the incremental Hazard Index is 1.17, and there is no incremental cancer risk. These incremental risk calculations indicate significant contribution to the Hazard Index from the COCs considering a residential land-use scenario.

## II.5 Step 7 Uncertainty Discussion

Voluntary corrective measures activities at Site 44b included radiation scanning to verify anomalies identified in 1994, removal of fragments and/or soil until readings were less than 1.3 times site-specific background levels, and post-cleanup (verification) soil sampling for gamma spectroscopy analysis. After the removal of radiologically contaminated soils, three samples were collected from areas exhibiting the highest residual radioactivity remaining in the soil. The sampling method was deemed sufficient to characterize the site. The nonradiological COCs were barium, beryllium, cadmium, chromium, lead, mercury, nickel, silver, and zinc. The radiological COCs were isotopic uranium, thorium (Th)-232, radium (Ra)-228, cesium (Cs)-137, and Cs-134. The nonradiological COCs were analyzed by EPA Methods 6010 and 7470. Isotopic uranium and Th-232 were analyzed by gamma spectroscopy. Ra-228, Cs-137, and Cs-134 were analyzed by gamma spectroscopy. The data provided by the laboratory are considered definitive data suitable for use in a risk assessment analysis.

The conclusion from the risk assessment analysis is that the potential effects on human health caused by nonradiological COCs are within the acceptable range compared to established numerical guidelines for the industrial land-use scenario. Calculated incremental risk between potential nonradiological COCs and associated background indicate small contribution of risk from nonradiological COCs when considering the industrial land-use scenario.

Since no radioactive COCs existed in excess of background concentrations a radiological risk assessment was not performed.

The potential effects on human health for the nonradiological COCs are greater when considering the residential land-use scenario. Incremental risk between potential nonradiological COCs and associated background also indicates a slightly increased contribution of risk from the nonradiological COCs. The increased effects on human health are primarily the result of including the plant uptake exposure pathway. Constituents that posed little to no risk considering an industrial land-use scenario (some of which are below background screening levels) contribute a significant portion of the risk associated with the residential land-use scenario. These constituents bioaccumulate in plants. Because Site 44b is designated as an industrial land-use area (DOE and USAF 1995), the likelihood of significant plant uptake in this area is highly unlikely. The uncertainty in this conclusion is considered to be small.

Because of the location, history of the site, and the future land-use (DOE and USAF 1995), there is low uncertainty in the land-use scenario and the potentially affected populations that were considered in making the risk assessment analysis. Because the COCs are found in surface and near-surface soils and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values, which means that the parameter values used in the calculations were conservative and that the calculated intakes are likely overestimates. Maximum measured values of the concentrations of the COCs and minimum value of the 95th UTL or percentile background concentration value, as applicable, of background concentrations associated with the COCs were used to provide conservative results.

Table 4 shows the uncertainties (confidence) in the nonradiological toxicological parameter values. There is a mixture of estimated values and values from the Health Effects Assessment Summary Tables (HEAST) (EPA 1996c) and Integrated Risk Information System (IRIS) (EPA 1988, 1997a) databases. Where values are not provided, information is not available from HEAST, IRIS, or EPA regions. Because of the conservative nature of the RME approach, the uncertainties in the toxicological values are not expected to be of high enough concern to change the conclusion from the risk assessment analysis.

The nonradiological risk assessment values are within the acceptable range for the industrial land-use scenario compared to the established numerical guidelines. Though the residential land-use Hazard Index is at the numerical guideline, it has been determined that future land-use at this locality will not be residential (DOE and USAF 1995). The overall uncertainty in all of the steps in the risk assessment process is considered insignificant with respect to the conclusion reached.

## II.6 Summary

ER Site 44b, the Decontamination Area, had relatively minor contamination consisting of some inorganic nonradioactive compounds. Because of the location of the site on KAFB, the designated industrial land-use scenario (DOE and USAF 1995), and the nature of the contamination, the potential exposure pathways identified for this site included soil ingestion and dust and volatile inhalation. Plant uptake was included as an exposure pathway for the residential land-use scenario. This site is designated for industrial land-use (DOE and USAF 1995); the residential land-use scenario is provided for perspective only.

Using conservative assumptions and employing an RME approach to the risk assessment, the calculations for the nonradiological COCs show that for the industrial land-use scenario, the Hazard Index (0.00) is significantly less than the accepted numerical guidance from the EPA. The estimated cancer risk ($1 \times 10^{-6}$) is in the low end of the suggested acceptable risk range. The incremental Hazard Index is 0.00, and the incremental cancer risk is $3 \times 10^{-8}$ for the industrial land-use scenario. Incremental risk calculations indicate insignificant risk to human health from the nonradiological COCs considering an industrial land-use scenario.

The main contributor to the nonradiological industrial land-use scenario risk assessment was beryllium. The maximum beryllium concentration (0.59 mg/kg) is below the background screening concentration of 0.80 mg/kg and therefore is not indicative of contamination.

The uncertainties associated with the calculations are considered small relative to the conservativeness of the risk assessment analysis. It is therefore concluded that this site does not have significant potential to affect human health under an industrial land-use scenario.

## III. Ecological Risk Assessment

### III.1 Introduction

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPEC) in soils from SNL/NM ER Site 44b. The ecological risk assessment process performed for this site is a screening level assessment that follows the methodology presented in IT Corporation (1997) and SNL/NM (1997). The methodology was based on screening level guidance presented by EPA (EPA, 1992; 1996d; 1997b) and by Wentsel et al. (1996) and is consistent with a phased approach. This assessment utilizes conservatism in the estimation of ecological risks; however, ecological relevance and professional judgment are also incorporated as recommended by EPA (1996d) and Wentsel et al. (1996) to ensure that the predicted exposures of selected ecological receptors reasonably reflect those expected to occur at the site.

### III.2 Ecological Pathways

The Decontamination Area (ER Site 44b) is part of Operable Unit 1303 and is located in TA-II. In general, the land within TA-II has been developed to its entirety (IT Corporation 1995). Essentially only limited suitable habitat (i.e., biological resources) remains in this area to sustain a viable ecological pathway between COPECs in surface and subsurface soil and plants and wildlife. Because some potential for exposure does exist, ecological risk predictions will be made.

### III.3 Constituents of Potential Ecological Concern

The potential COCs at this site include some RCRA metals, beryllium, nickel, and several radionuclides. Following the screening process used for the selection of potential COCs for the human health risk assessment, the inorganic COCs were screened against background UTLs. Six inorganic analytes were identified a COPECs at Site 44b: cadmium, chromium (total), lead, mercury, silver, and zinc. Chemicals that are essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, were not included in this risk assessment per EPA guidance (EPA 1989). No detected radionuclides exceeded background concentrations.

## III.4 Receptors and Exposure Modeling

A nonspecific perennial plant was used as the receptor to represent plant species at the site. Two wildlife receptors (deer mouse and burrowing owl) were used to represent wildlife use of the site. Exposure modeling for the wildlife receptors was limited to the food ingestion pathway. Inhalation and dermal contact were considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Drinking water was also considered an insignificant pathway because of the lack of surface water at this site. The deer mouse was modeled as an omnivore (50 percent of the diet as plants and 50 percent as soil invertebrates), and the burrowing owl was modeled as a strict predator on small mammals (100 percent of the diet as deer mice). Both were modeled with soil ingestion comprising 2 percent of the total dietary intake. Table 7 presents the species-specific factors used in modeling exposures in the wildlife receptors. Although home range is also included in this table, exposures for this screening-level assessment were modeled using an area use factor of 1, implying that all food items and soil ingested are from the site being investigated.

The maximum measured COPEC concentrations from both surface and subsurface soil samples were used to conservatively estimate potential exposures and risks to plants and wildlife at this site. One-half the detection limit was used for silver from the on-site laboratory, which was not otherwise detected but was retained due to the high detection limit.

Table 8 presents the transfer factors used in modeling the concentrations of the nonradioactive COPECs through the food chain. Table 9 presents the maximum concentrations of the nonradioactive COPECs in soil, the derived concentrations in the various food-chain elements, and the modeled dietary exposures for each of wildlife receptor species.

## III.5 Toxicity Benchmarks

Benchmark toxicity values for the plant and wildlife receptors are presented in Table 10. For plants, the benchmark soil concentrations are based on the lowest-observed-adverse-effect level (LOAEL). For wildlife, the toxicity benchmarks are based on the no-observed-adverse-effect level (NOAEL) for chronic oral exposure in a taxonomically similar test species. Total chromium was assumed to be entirely chromium-VI. Insufficient toxicity information was found to estimate the NOAELs for birds exposed to silver.

## III.6 Risk Characterization

The maximum soil concentrations and estimated dietary exposures were compared to plant and wildlife benchmark values, respectively. The results of these nonradiological comparisons are presented in Table 11. Hazard quotients (HQ) are used to quantify the comparison with the benchmarks for wildlife exposure. Maximum soil concentrations for chromium (total), mercury, and zinc exceeded their respective plant benchmark concentrations. No potential risk was predicted for the deer mouse. For the burrowing owl, only the HQ for mercury (HQ = 4.70) exceeded unity.

**Table 7**
**Exposure Factors for Ecological Receptors at Environmental Restoration Site 44b, Sandia National Laboratories, New Mexico**

| Receptor Species | Class/ Order | Trophic level | Body weight (kg)[a] | Food intake rate (kg/d)[b] | Dietary Composition[c] | Home range (acres) |
|---|---|---|---|---|---|---|
| Deer Mouse (*Peromyscus maniculatus*) | Mammalia/ Rodentia | Omnivore | 0.0239[d] | 0.00372 | Plants: 50% Invertebrates: 50% (+ Soil at 2% of intake) | 0.27[e] |
| Burrowing owl (*Speotyto cunicularia*) | Aves/ Strigiformes | Carnivore | 0.155[f] | 0.0173 | Rodents: 100% (+ Soil at 2% of intake) | 34.6[g] |

[a]Body weights are in kilograms wet weight.
[b]Food intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kilograms dry weight per day.
[c]Dietary compositions are generalized for modeling purposes. Default soil intake value of 2 percent of food intake.
[d]From Silva and Downing (1995).
[e]From EPA (1993), based on the average home range measured in semi-arid shrubland in Idaho.
[f]From Dunning (1993).
[g]From Haug et al. (1993).

**Table 8**
**Transfer Factors Used in Exposure Models for Constituents of Potential Ecological Concern at Environmental Restoration Site 44b, Sandia National Laboratories, New Mexico**

| Constituent of Potential Ecological Concern | Soil-to-Plant Transfer Factor | Soil-to-Invertebrate Transfer Factor | Food-to-Muscle Transfer Factor |
|---|---|---|---|
| Cadmium | $5.50 \times 10^{-1}$ | $6.00 \times 10^{-1}$ | $5.50 \times 10^{-4}$ |
| Chromium (Total) | $4.00 \times 10^{-2}$ [a] | $1.30 \times 10^{-1}$ [b] | $3.00 \times 10^{-2}$ [a] |
| Mercury | $1.00 \times 10^{0}$ [c] | $1.00 \times 10^{0}$ [d] | $2.50 \times 10^{-1}$ [d] |
| Lead | $9.00 \times 10^{-2}$ | $4.00 \times 10^{-2}$ | $8.00 \times 10^{-4}$ |
| Silver | $1.00 \times 10^{0}$ [c] | $2.50 \times 10^{-1}$ [e] | $5.00 \times 10^{-3}$ [a] |
| Zinc | $1.50 \times 10^{0}$ [d] | $3.00 \times 10^{-1}$ [a] | $1.00 \times 10^{-1}$ [c] |

[a]From Baes et al. (1984).
[b]From Stafford et al. (1991).
[c]Default value.
[d]From NCRP (1989).
[e]From Ma (1982).

**Table 9**
**Media Concentrations (mg/kg)[a] for Constituents of Potential Ecological Concern at Environmental Restoration Site 44b, Sandia National Laboratories, New Mexico**

| Constituent of Potential Ecological Concern | Soil (maximum) | Plant Foliage[b] | Soil Invertebrate[b] | Deer Mouse Tissues[c] |
|---|---|---|---|---|
| Cadmium | $7.00 \times 10^{-1}$ | $3.85 \times 10^{-1}$ | $4.20 \times 10^{-1}$ | $7.16 \times 10^{-4}$ |
| Chromium (Total) | $9.30 \times 10^{0}$ | $3.72 \times 10^{-1}$ | $1.21 \times 10^{0}$ | $9.15 \times 10^{-2}$ |
| Lead | $2.57 \times 10^{+1}$ | $2.31 \times 10^{0}$ | $1.03 \times 10^{0}$ | $5.46 \times 10^{-3}$ |
| Mercury | $3.30 \times 10^{-1}$ | $3.30 \times 10^{-1}$ | $3.30 \times 10^{-1}$ | $2.63 \times 10^{-1}$ |
| Silver | $5.00 \times 10^{-1}$ | $5.00 \times 10^{-1}$ | $1.25 \times 10^{-1}$ | $5.04 \times 10^{-3}$ |
| Zinc | $8.41 \times 10^{1}$ | $1.26 \times 10^{2}$ | $2.52 \times 10^{1}$ | $2.42 \times 10^{1}$ |

[a]Milligrams per kilogram. All are based on dry weight of the media.
[b]Product of the soil concentration and the corresponding transfer factor.
[c]Product of the average concentration in food times the food-to-muscle transfer factor times the wet weight-dry weight conversion factor of 3.125 (from EPA 1993).

**Table 10**
**Toxicity Benchmarks for Ecological Receptors at Environmental Restoration Site 44b, Sandia National Laboratories, New Mexico**

| | | Mammalian NOAELs | | | Avian NOAELs | | |
|---|---|---|---|---|---|---|---|
| Constituent of Potential Ecological Concern | Plant Benchmark[a] | Mammalian Test Species[b] | Test Species NOAEL[c] | Deer Mouse NOAEL[d] | Avian Test Species[e] | Test Species NOAEL[e] | Burrowing Owl NOAEL[f] |
| Cadmium | 3 | Lab rat | 1 | 1.69 | Mallard | 1.45 | 1.45 |
| Chromium (Total) | 1 | Lab rat | 2737 | 5354 | Black Duck | 1.0 | 1.0 |
| Lead | 50 | Lab rat | 8 | 15.65 | Am. Kestrel | 3.85 | 3.85 |
| Mercury | 0.3 | Lab rat | 0.032 | 0.0626 | Mallard | 0.0064 | 0.0064 |
| Silver | 2 | Lab rat[g] | 17.8[g] | 34.8 | --[h] | -- | -- |
| Zinc | 50 | Lab rat | 160 | 313 | Chicken | 14.5 | 14.5 |

[a]From Will and Suter (1995).
[b]From Sample et al. (1996), except where noted. Body weights (in kilograms) for NOAEL conversion are: lab mouse, 0.030; lab rat, 0.350 (except where noted); and mink, 1.0.
[c]From Sample et al. (1996), except where noted.
[d]Based on NOAEL conversion methodology presented in Sample et al. (1996), using a deer mouse body weight of 0.239 kilograms and a mammalian scaling factor of 0.25.
[e]From Sample et al. (1996).
[f]Based on NOAEL conversion methodology presented in Sample et al. (1996). The avian scaling factor of 0.0 was used, making the NOAEL independent of body weight.
[g]From EPA (1997b).
[h]-- designates insufficient toxicity data.

**Table 11**
**Comparisons to Toxicity Benchmarks for Ecological Receptors at Environmental Restoration Site 44b, Sandia National Laboratories, New Mexico**

| Constituent of Potential Ecological Concern | Plant Hazard Quotient[a] | Deer Mouse Hazard Quotient | Burrowing Owl Hazard Quotient |
|---|---|---|---|
| Cadmium | $2.33 \times 10^{-1}$ | $3.44 \times 10^{-2}$ | $1.13 \times 10^{-3}$ |
| Chromium (Total) | **$9.30 \times 10^{0}$** | $2.84 \times 10^{-5}$ | $3.09 \times 10^{-2}$ |
| Lead | $5.14 \times 10^{-1}$ | $2.17 \times 10^{-2}$ | $1.50 \times 10^{-2}$ |
| Mercury | **$1.10 \times 10^{0}$** | $6.37 \times 10^{-1}$ | **$4.70 \times 10^{0}$** |
| Silver | $2.50 \times 10^{-1}$ | $1.44 \times 10^{-3}$ | ---[b] |
| Zinc | **$1.68 \times 10^{0}$** | $3.85 \times 10^{-2}$ | $1.99 \times 10^{-1}$ |

[a]**Bold** text indicates hazard quotient greater than unity.
[b]--- designates insufficient toxicity data available for risk estimation purposes.

## III.7 Uncertainties

Many uncertainties are associated with the characterization of ecological risks at ER Site 44b. These uncertainties result in the use of assumptions in estimating risk that may lead to an overestimation or underestimation of the true risk presented at a site. For this screening level risk assessment, assumptions are made that are more likely to overestimate risk rather than to underestimate it. These conservative assumptions are used to be more protective of the ecological resources potentially affected by the site. Conservatisms incorporated into this risk assessment include the use of the maximum measured soil concentration or detection limits (an amount equal to one-half of the detection limit) to evaluate risk, the use of wildlife toxicity benchmarks based on NOAEL values, the use of earthworm-based transfer factors or a default factor of 1.0 for modeling COPECs into soil invertebrates in the absence of insect data, and the use of 1.0 as the area use factor for wildlife receptors regardless of seasonal use or home range size.

## III.8 Summary

Potential risks were indicated for two of the three ecological receptors at ER Site 44b; however, the use of the maximum measured soil concentration or one-half the maximum detection limit to evaluate risk provided a conservative exposure scenario for the risk assessment and may not reflect actual site conditions. Detection limits, at half value, were used to evaluate risk for silver. Maximum measured soil concentrations for chromium (total), mercury, and zinc exceeded their respective plant benchmark concentrations. Although risk was predicted to plants exposed to chromium at this site, the maximum total chromium concentration is actually less than the background value of 12.8 mg/kg. No potential risk was predicted for the deer mouse from nonradioactive COPECs. Mercury was the only COPEC concentration that resulted in an HQ greater than 1.0 for the burrowing owl. Because of the home range of the owl is more than 20 times the size of the site, the true risk for the burrowing owl due to mercury from Site 44b is insignificant. Based on these results, silver and chromium can be justified for elimination as a COPECs at ER Site 44b; The incremental risk resulted from zinc, subtracting the background, would produce an HQ of 0.2. However, it is very likely that the other risk results are driven by conservatisms in data analysis. HQs based on 95 percent upper confidence limits of the mean will likely be lower and still be a conservative estimate of site conditions. Overall ecological risks associated with ER Site 44b are expected to be low.

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**APPENDIX 1.**

## Sandia National Laboratories Environmental Restoration Program

## EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION

## BACKGROUND

Sandia National Laboratories (SNL) proposes that a default set of exposure routes and associated default parameter values be developed for each future land-use designation being considered for SNL/NM Environmental Restoration (ER) project sites. This default set of exposure scenarios and parameter values would be invoked for risk assessments unless site-specific information suggested other parameter values. Because many SNL/NM ER sites have similar types of contamination and physical settings, SNL believes that the risk assessment analyses at these sites can be similar. A default set of exposure scenarios and parameter values will facilitate the risk assessments and subsequent review.

The default exposure routes and parameter values suggested are those that SNL views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the USEPA Region VI and NMED, SNL proposes that these default exposure routes and parameter values be used in future risk assessments.

At SNL/NM, all Environmental Restoration sites exist within the boundaries of the Kirtland AFB. Approximately 157 potential waste and release sites have been identified where hazardous, radiological, or mixed materials may have been released to the environment. Evaluation and characterization activities have occurred at all of these sites to varying degrees. Among other documents, the SNL/ER draft Environmental Assessment (DOE 1996) presents a summary of the hydrogeology of the sites, the biological resources present and proposed land use scenarios for the SNL/NM ER sites. At this time, all SNL/NM ER sites have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based on a residential land use scenario. All three land use scenarios will be addressed in this document.

The SNL/NM ER project has screened the potential exposure routes and identified default parameter values to be used for calculating potential intake and subsequent hazard index, risk and dose values. EPA (EPA 1989a) provides a summary of exposure routes that could potentially be of significance at a specific waste site. These potential exposure routes consist of:

- Ingestion of contaminated drinking water;
- Ingestion of contaminated soil;
- Ingestion of contaminated fish and shell fish;
- Ingestion of contaminated fruits and vegetables;
- Ingestion of contaminated meat, eggs, and dairy products;
- Ingestion of contaminated surface water while swimming;
- Dermal contact with chemicals in water;
- Dermal contact with chemicals in soil;
- Inhalation of airborne compounds (vapor phase or particulate), and;

- External exposure to penetrating radiation (immersion in contaminated air; immersion in contaminated water and exposure from ground surfaces with photon-emitting radionuclides).

Based on the location of the SNL ER sites and the characteristics of the surface and subsurface at the sites, we have evaluated these potential exposure routes for different land use scenarios to determine which should be considered in risk assessment analyses (the last exposure route is pertinent to radionuclides only). At SNL/NM ER sites, there does not presently occur any consumption of fish, shell fish, fruits, vegetables, meat, eggs, or dairy products that originate on-site. Additionally, no potential for swimming in surface water is present due to the high-desert environmental conditions. As documented in the RESRAD computer code manual (ANL 1993), risks resulting from immersion in contaminated air or water are not significant compared to risks from other radiation exposure routes.

For the industrial and recreational land use scenarios, SNL/NM ER has therefore excluded the following four potential exposure routes from further risk assessment evaluations at any SNL/NM ER site:

- Ingestion of contaminated fish and shell fish;
- Ingestion of contaminated fruits and vegetables;
- Ingestion of contaminated meat, eggs, and dairy products; and
- Ingestion of contaminated surface water while swimming.

That part of the exposure pathway for radionuclides related to immersion in contaminated air or water is also eliminated.

For the residential land-use scenario, we will include ingestion of contaminated fruits and vegetables because of the potential for residential gardening.

Based on this evaluation, for future risk assessments, the exposure routes that will be considered are shown in Table 1. Dermal contact is included as a potential exposure pathway in all land use scenarios. However, the potential for dermal exposure to inorganics is not considered significant and will not be included. In general, the dermal exposure pathway is generally considered to not be significant relative to water ingestion and soil ingestion pathways but will be considered for organic components. Because of the lack of toxicological parameter values for this pathway, the inclusion of this exposure pathway into risk assessment calculations may not be possible and may be part of the uncertainty analysis for a site where dermal contact is potentially applicable.

## EQUATIONS AND DEFAULT PARAMETER VALUES FOR IDENTIFIED EXPOSURE ROUTES

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation may also be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land use scenarios. The general equations for calculating potential intakes via

**Table 1. Exposure Pathways Considered for Various Land Use Scenarios**

| Industrial | Recreational | Residential |
|---|---|---|
| | | |
| Ingestion of contaminated drinking water | Ingestion of contaminated drinking water | Ingestion of contaminated drinking water |
| Ingestion of contaminated soil | Ingestion of contaminated soil | Ingestion of contaminated soil |
| Inhalation of airborne compounds (vapor phase or particulate) | Inhalation of airborne compounds (vapor phase or particulate) | Inhalation of airborne compounds (vapor phase or particulate) |
| Dermal contact | Dermal contact | Dermal contact |
| External exposure to penetrating radiation from ground surfaces | External exposure to penetrating radiation from ground surfaces | Ingestion of fruits and vegetables |
| | | External exposure to penetrating radiation from ground surfaces |

these routes are shown below. The equations are from the Risk Assessment Guidance for Superfund (RAGS): Volume 1 (EPA 1989a and 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL 1993). Also shown are the default values SNL/NM ER suggests for use in Reasonable Maximum Exposure (RME) risk assessment calculations for industrial, recreational, and residential scenarios, based on EPA and other governmental agency guidance. The pathways and values for chemical contaminants are discussed first, followed by those for radionuclide contaminants. RESRAD input parameters that are left as the default values provided with the code are not discussed. Further information relating to these parameters may be found in the RESRAD Manual (ANL 1993).

<u>Generic Equation for Calculation of Risk Parameter Values</u>

The equation used to calculate the risk parameter values (i.e., Hazard Quotient/Index, excess cancer risk, or radiation total effective dose equivalent [dose]) is similar for all exposure pathways and is given by:

Risk (or Dose) = Intake x Toxicity Effect (either carcinogenic, noncarcinogenic, or radiological)

$$= C \times (CR \times EFD/BW/AT) \times \text{Toxicity Effect} \qquad (1)$$

where

- C = contaminant concentration (site specific);
- CR = contact rate for the exposure pathway;
- EFD = exposure frequency and duration;
- BW = body weight of average exposure individual;
- AT = time over which exposure is averaged.

The total risk/dose (either cancer risk or hazard index) is the sum of the risks/doses for all of the site-specific exposure pathways and contaminants.

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk range of $10^{-4}$ to $10^{-6}$. The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the Hazard Index) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard Hazard Index of unity (1). The evaluation of the health hazard due to radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA 1989a) and the RESRAD Manual (ANL 1993). Table 2 shows the default parameter values suggested for used by SNL at ER sites, based on the selected land use scenario. References are given at the end of the table indicating the source for the chosen parameter values. The intention of SNL is to use default values that are consistent with regulatory guidance and consistent with the RME approach. Therefore, the values chosen will, in general, provide a conservative estimate of the actual risk parameter. These parameter values are suggested for use for the various exposure pathways based on the assumption that a particular site has no unusual characteristics that contradict the default assumptions. For sites for which the assumptions are not valid, the parameter values will be modified and documented.

Summary

SNL proposes the described default exposure routes and parameter values for use in risk assessments at sites that have an industrial, recreational or residential future land-use scenario. There are no current residential land-use designations at SNL ER sites, but this scenario has been requested to be considered by the NMED. For sites designated as industrial or recreational land-use, SNL will provide risk parameter values based on a residential land-use scenario to indicate the effects of data uncertainty on risk value calculations or in order to potentially mitigate the need for institutional controls or restrictions on Sandia ER sites. The parameter values are based on EPA guidance and supplemented by information from other government sources. The values are generally consistent with those proposed by Los Alamos National Laboratory, with a few minor variations. If these exposure routes and parameters are acceptable, SNL will use them in risk assessments for all sites where the assumptions are consistent with site-specific conditions. All deviations will be documented.

**Table 2. Default Parameter Values for Various Land Use Scenarios**

| Parameter | Industrial | Recreational | Residential |
|---|---|---|---|
| **General Exposure Parameters** | | | |
| Exposure frequency (d/y) | *** | *** | *** |
| Exposure duration (y) | 30[a,b] | 30[a,b] | 30[a,b] |
| Body weight (kg) | 70[a,b] | 56[a,b] | 70 adult[a,b]<br>15 child |
| Averaging Time (days)<br>for carcinogenic compounds<br>(=70 y x 365 d/y)<br>for noncarcinogenic compounds<br>(=ED x 365 d/y) | 25550[a]<br><br>10950 | 25550[a]<br><br>10950 | 25550[a]<br><br>10950 |
| | | | |
| **Soil Ingestion Pathway** | | | |
| Ingestion rate | 100 mg/d[c] | 6.24 g/y[d] | 114 mg-y/kg-d[a] |
| | | | |
| **Inhalation Pathway** | | | |
| Inhalation rate ($m^3$/yr) | 5000[a,b] | 146[d] | 5475[a,b,d] |
| Volatilization factor ($m^3$/kg) | chemical specific | chemical specific | chemical specific |
| Particulate emission factor ($m^3$/kg) | 1.32E9[a] | 1.32E9[a] | 1.32E9[a] |
| | | | |
| **Water Ingestion Pathway** | | | |
| Ingestion rate (L/d) | 2[a,b] | 2[a,b] | 2[a,b] |
| | | | |
| **Food Ingestion Pathway** | | | |
| Ingestion rate (kg/yr) | NA | NA | 138[b,d] |
| Fraction ingested | NA | NA | 0.25[b,d] |
| | | | |
| **Dermal Pathway** | | | |
| Surface area in water ($m^2$) | 2[b,e] | 2[b,e] | 2[b,e] |
| Surface area in soil ($m^2$) | 0.53[b,e] | 0.53[b,e] | 0.53[b,e] |
| Permeability coefficient | chemical specific | chemical specific | chemical specific |

*** The exposure frequencies for the land use scenarios are often integrated into the overall contact rate for specific exposure pathways. When not included, the exposure frequency for the industrial land use scenario is 8 h/d for 250 d/y; for the recreational land use, a value of 2 hr/wk for 52 wk/y is used (EPA 1989b); for a residential land use, all contact rates are given per day for 350 d/y.

[a] RAGS, Vol 1, Part B (EPA 1991).

[b] Exposure Factors Handbook (EPA 1989b)

[c] EPA Region VI guidance.

[d] For radionuclides, RESRAD (ANL 1993) is used for human health risk calculations; default parameters are consistent with RESRAD guidance.

[e] Dermal Exposure Assessment (EPA 1992).

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